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LESTER'S PENDULUM ENGINE.

(Concluded, from p. 277.)

Another circumstance in favor of this machine, is, that the variation of the length of the cylinder and projected part of the piston-rod taken together, (which length is greater or less, as the piston-rod is more or less projected from the cylinder in the course of the revolution of the crank,) gives it a mechanical advantage over the fixed engine. In turning a crank with a connecting-rod, one end of which holds upon a pin at the end of the crank, the other end, at which the power is applied, is either fixed to one point, as in the Pendulum Engine, or moves in a straight line, forward and backward, a distance of twice the length of the crank, as in the connecting-rod of the fixed engine; it is evident that the longer this connecting-rod is, the more advantageously the power will act upon the crank-pin in the part of its circle most distant from the power; and the shorter it is, the more advantageously the power will act when the crank-pin is in the nearest part of the circle. In the Pendulum Engine the cylinder and projected part of the piston-rod, together, serve instead of the connecting-rod, and the length of these two together is greatest when the crank-pin is in the most distant part of its circle, and least, when it is in the nearest part, and varies constantly between the two extremes, becoming gradually longer in approaching the distant part, and gradually shorter in approaching the nearest part. Here, then, is a positive mechanical advantage gained by the Pendulum Engine over the fixed engine, without any sacrifice or special application of power for this purpose. It is an advantage arising spontaneously from the principles of the operation of the machine, the exact amount of which, taking given lengths of the connecting-rod in one case, and of the cylinder and piston-rod in the other, may be mathematically calculated, though to compute it with precision, would require a calculation somewhat complicated. This gain is the greatest in the shortest lengths, in comparison with the cranks, in the two cases, and diminishes, but still exists, as they are increased. Taking the average of those comparative lengths in the ordinary proportions of construction, I think it safe to estimate the saving of power from this cause at from three to four per cent.

Another advantage in the plan and construction of this engine, remaining to be mentioned, arises from its working in a frame, the parts of which always maintain the same relation to each other, and, as it has in its operation no tendency to displace any fixtures or disturb the foundation, a great expense is saved in these respects, in putting up the engine, more especially in places where it is difficult to get a good foundation. The Pendulum Engine only requires a foundation sufficient merely to support the *weight*, without any necessity of providing for extraneous resistance to the action of the machine itself, as in the case of a fixed engine.

On this engine being first put into operation, a query was suggested whether it would have a greater tendency, than a fixed engine, to wear the cylinder ovaling or untrue. I felt great confidence, from the first, that it would not prove to be liable to this objection, and experience has fully shown, as will appear from the certificates annexed, that with any reasonable skill and care in keeping it packed, it will wear perfectly true, which is not always the case with fixed engines even with the greatest attention of the engineer. So far, therefore, from there being any objection to it in this respect, it might be enumerated as one of its advantages, that it is less liable to wear the cylinder unequally, than a fixed engine; though there is no doubt that an engine, on this or any other plan, may wear the cylinder unequally, in case of gross negligence in keeping it packed.

Such are, in my estimation, the advantages of the Pendulum Engine. To what

precise degree, or rate per cent. of saving, they amount, I will not undertake to estimate. Mr. Burt, whose certificate is annexed, and who is a scientifick machinist, possessing, at the same time, a great deal of practical experience in mechanicks, estimates the advantages of this engine at twenty per cent. over those having a fixed cylinder. Whether they amount to so very great a proportion as this, I refer to the consideration of intelligent engineers and mechanicians.

It is no object with me, nor would it, in the event, be any benefit to me, to induce any person to form an exaggerated opinion of the advantages of the Pendulum Engine. I prefer that its reputation with the publick, should be such only as shall be founded in the strictest truth. At the same time I will not affect to conceal my entire confidence, that the more it is examined and proved, and the better it is understood, the more it will recommend itself.

As practical application and use are the true tests of all machinery, I have requested some persons who have been acquainted with the operation of this engine, to make statements of the results of their experience and observation. Their statements are annexed. They are made by persons who have no interest whatever in obtaining for the machine a better reputation than it merits. Some of them are persons of mechanical science, others are practical engineers; and a number of them are sufficiently well known to the publick, to insure confidence in their statements and opinions.

There is one application of steam engines which now excites great interest, I mean that to locomotion on land, to which, though no direct experiment of the kind has been yet made with the Pendulum Engine, I think it is well adapted. As soon as engines shall be required in the United States for this purpose, I shall make an experiment to test its qualities in this respect. Some intelligent engineers have expressed an opinion that it is decidedly the best plan of construction of an engine for this use.

EBENEZER A. LESTER.

Boston, August 2, 1830.

CERTIFICATES.

Charlestown, June 14th, 1830.

Being requested by Mr. Ebenezer A. Lester, to make a statement respecting his Pendulum Engine, I can say, in the first place, that I have had charge of steam engines, and worked upon them, and acted as an engineer, the last twelve years. I have worked low-pressure engines on Bolton and Watt's plan, and also high-pressure engines. I have been employed about half of the time above-mentioned, at Baltimore, and the rest in Boston and Charlestown. About three years ago, when Mr. Lester stated to me the plan of his Pendulum Engine, I objected to it on account of its swinging, thinking that it would injure the packing, and be liable to get out of order. About two years ago one of his Pendulum Engines was put in operation at the Navy Yard in Charlestown, in Massachusetts; this engine I put up, the same having been made by Mr. Lester, at his works in Boston, and I have run it ever since it was put up, and it has been running pretty much all the time, day and night; it has run about two-thirds of each twenty-four hours; and I have found, from my experience, that the engine is superior to those on the old plan, in those points in which I, at first, supposed it would be defective. There is less friction on the piston; the packing does not wear so much, and the engine is not so liable to get out of order. The last packing of this engine run seven months and a half. The packing of one on the old plan, is commonly required to be changed from once a fortnight, to once a month, and more frequently in a high, than in a low pressure engine. I am confident, that a high pressure engine on the old plan, in doing the work of this engine, would have required the packing to be renewed, at least once in three weeks. The injury to the packing, and the frequency of renewing it, is one important test of the friction of the engine, as every engineer very well knows; and the circumstance of this packing running so long, is a clear proof, that there is a very great saving of friction in this engine. The first packing ever put into it, run four months, when the cylinder was in a rough state; the next packing run six months. The last time this engine was packed, which was about six weeks ago, I tried the cylinder to ascertain whether the inside was worn, and how it was worn, if at all; but I found it to be perfectly true. The reason for making this examination, was, that it had been said, as I was told, that the inside of the cylinder of an engine upon this plan, would wear oval; I was accordingly induced to examine this engine particularly, as above stated, and found it not to be worn in the last out of true. I think, one very great superiority of this engine, is, the advantage the construction gives for passing the dead centre, which it passes with more ease and power, so that it will have a greater effect on the crank, and operate with a greater power, than one on the old plan, of the same size, and with the same force of steam. This advantage is derived partly from the assistance that the weight of the engine gives in passing the centre. It also saves all the friction of the slides, which

cannot be avoided in engines on the old construction. One reason of its being less liable to get out of order, is, that there is no gearing to be used betwen the piston-rod and crank, whereas the gearing of this description required by the engines, upon the other plans, increases the friction, and also is more or less liable to get out of order.

The engine in operation in this navy yard, is a nine-inch cylinder, of a twenty-eight inch stroke. The work required of it varies; it is used for pumping out the dry dock, and also has four lathes, and two grindstones attached to it. At times it has driven these lathes, and the grindstones, and two large pumps of a foot diameter each, and four smaller ones of six inches diameter. The large pumps lift a column of water of about forty feet, and the weight is estimated to be about a ton each. The four smaller ones, lift sixteen feet, making a weight of about two hundred pounds each, 4800 pounds in the whole. The crank of the engine, as will appear from the length of stroke already mentioned, is fourteen inches. The strokes of the large pumps, with the cranks heretofore in use, have been thirty-two inches and three quarters, and those of the smaller ones, twenty-four inches. The strokes of the pumps are to those of the engine, in time, as 7 to 25. The engine is calculated to run sixty revolutions a minute, and is ordinarily worked at about that rate. With the present boiler, being a cylinder of 18 feet long by 3 feet diameter,* the engine has been driven seventy revolutions a minute, and with a larger boiler, might be driven with safety at a much greater speed; I should say at least, at a hundred revolutions per minute. And as far as my experience goes, I should say that increasing the velocity, would, in this engine, be a greater gain in the application of the power, that is, it could be made with greater economy; and the gain by increasing the power, by an increase of the velocity, is, I am confident, greater in this engine, than in those of the old construction. The lathes above mentioned, are used for turning iron and wood.

Since this engine has been in operation, not one dollar has been laid out in repairs upon it. NOAH BUTTS.

Dry Dock Office, Charlestown Navy Yard,
June 21, 1830.

Dear Sir,

Engagements have hitherto prevented my answering your inquiries concerning the oscillating steam engine, made and erected by Mr. Lester, which is now employed in draining the works of the Dock. I now make the following statement, referring you for further particulars to the certificate of Mr. Butts, the engineer, who assisted in setting it up, and who has ever since been engaged in directing its operations.

The engine was first set to work in May, 1828, and has ever since been daily used in pumping water from the foundation of the Dock. No part of the machinery has given way, nor has the engine failed to do all the work which was required. It has, in every respect, answered my expectation, and were I to engage in a similar undertaking, I would obtain a similar engine for the same service. Its simplicity and compactness render it peculiarly adapted to constructions like the Dock, where a slight and temporary foundation only can be had. I have always viewed its operation with peculiar pleasure, and am convinced that it has been more economical than any other engine of the same power, I could have procured. I regret I had not provided one like it for draining the works of the Norfolk Dock in Virginia.

With great esteem, your obed't servt.
L. BALDWIN.

WILLARD PHILLIPS, Esq. Boston.

BOSTON, May 21st. 1830.

Having been employed during the two past years at the Navy Yard in Charlestown, during which time one of Mr. Ebenezer A. Lester's Pendulum Engines has been constantly in operation there in pumping out the dry dock, my attention has been attracted both to the principle upon which it is constructed and to its practical operation. I will not undertake to say how powerful an engine may be advantageously constructed and operated upon the principle of this one, nor whether it may be best adapted to a large or a small engine, but I am well satisfied that for an engine not exceeding a twenty horse-power, the principle is entirely unexceptionable, and has some circumstances which strongly recommend it. One advantage, which is obvious to every mechanick on the first inspection of this engine, is its great simplicity and compactness of construction, which is attained without the sacrifice of any mechanical advantage in the application of the power to the crank. If there is any difference between this and the common engines in this respect, it is in favor of the Pendulum Engine. But I proceed upon the supposition that the mechanical power of the same force of steam upon the square inch in this engine, upon the crank, is the same as in other engines, though some persons, as I understand, suppose there is a gain in this respect in favor of the Pendulum Engine, of from five to eight per cent. the degree or rate depending partly upon the comparative lengths of the piston-rod and crank—and connecting-rod, (say, if such be used) and crank—in the two cases. How this may be, I will not venture to express an opinion; but suppos-

*The engine is ordinarily operated with steam power, 20 to 30lbs. per inch, and occasionally at 35lbs per inch.

ing the differen engines to be equal in this respect, still the Pendulum Engine, by dispensing with the connecting-rod, lever-beam, and every other species of gearing and machinery ordinarily interposed between the piston-rod and crank, saves the friction of all this intermediate gearing and machinery, and all the joints requisite in such gearing, and consequently avoids the inconveniencies arising frequently from this machinery, and especially the joints getting out of order, and also avoids the expense of repairs thereby rendered necessary. This advantage is so great, and at the same time so obvious to any mechanick, or any person in the least conversant with machinery, that it is unnecessary that I should point it out or specify it more particularly. It appears to me to be a very material and important circumstance in favor of this species of engine.

Although I have spoken of an engine within a twenty horse-power, I do not intend thereby to imply an opinion as to the extent of power to which engines of this description may be advantageously used; perhaps engines of any size may be advantageously constructed upon this plan, keeping within certain limits as to the velocity of the vibratory motion of the engine itself, one obvious way of doing which, without the use of any gearing, would be by lengthening the piston-rod, for the longer the piston-rod is, the length of the crank remaining the same, the less will be the vibratory motion of the engine to produce a given number of revolutions. I have put the above limit as to the size of the engine, therefore, merely that I may keep within my practical experience and observation respecting this engine; nor do I suggest the above remedy for too great a velocity or motion of the engine from any distinct opinion that any precaution of this sort may be necessary, for it may turn out that the vibrations will not be too rapid in an engine of any size, if it be operated so that the strokes are not more rapid than is consistent with the most economical use of steam. It is a question then whether the engine is liable to any difficulty of this sort though it should be of a much larger size than I have above specified; and if it be liable at all, it is a case that would seem to admit of an easy remedy.

It is not necessary to remind persons, who are at all conversant with steam engines, that, upon whatever plan they may be constructed, their operation and success, depends very materially upon the skill and care of the engineer who has the management and superintendence of them when in operation. An engine on Mr. Lester's plan, or on any other plan, will be liable to get out of order, and be subject to derangement, if not properly and skilfully managed. But I think Mr. Lester's engine will be less liable to derangement, than those on the old plan, provided the skill and care of the engineers, who operate them, is the same. The engine at the dry dock, has done a good deal of work, having been in operation day and night, for two years, and I can confidently say, that no engine could have operated better, and I think, that one on the old plan, could not have been kept in operation so long a time, for so little expense of repairs.

Some have suggested that this engine, by use for any length of time, will wear the cylinder, so as to make it elliptical on the inside, and thus render it difficult to keep it well packed. This is an entire mistake; the engine at Charlestown, has been repeatedly examined, and no appearance whatever of this kind, is observable. On the contrary, the packing has stood remarkably well, and required very little renewing.

ALEXANDER PARRIS.
Superintendent of Dry Dock, Charlestown Navy Yard.

We the undersigned having been employed at the Navy Yard in Charlestown, and having daily seen the operation of the Pendulum Engine erected by Mr. Lester at the Dry Dock, since its erection, do hereby certify, that for simplicity in its construction, durability in its parts, and effects in its operations, in our opinion it is superior to any other plan of engine (with which we are acquainted) now in use, and from the combinations and arrangements of the machinery, it may be operated in situations where, for want of firm and solid foundations, other plans of engines could not be erected.

EDWARD BATTLES, WM. BUTTS,
WM. ANDEM, B. BAKER,
B. F. PERHAM, A. BATES,
W. BECKFORD, J. TURNER.

Navy Yard, Charlestown, July 14, 1830.

Boston, July 28th, 1830.

Dear Sir,

I am well acquainted with the arrangements of Mr. Lester's Pendulum Steam Engine, and have always entertained a favourable opinion of it, so far as I could exercise my judgment, without having an opportunity of studying accurately its practical performance. Mr. Lester, before he had constructed one, communicated to me his plan, on which we frequently conversed. It seemed to promise many advantages, and the only doubt, which occurred to my mind, was whether the cylinder might not become oval. This, it is whispered *is* the defect, but on inquiry I cannot trace the report to any fact, and am inclined to think it has arisen from that unmanly, malignant spirit of detraction, which so often attempts to check the progress of improvement. Mr. Lester's belief always was, that his cylinder would be less liable to be worn out of true, than one fixed, and results have supported his conclusion, or at least have proved that it is not peculiarly subject to this injury. An engine erected

by him for the use of the Dry Dock at the Navy Yard, Charlestown, which has frequently come under my observation, has now been in operation more than two years, day and night, a sufficient time to detect such an imperfection if it existed. The person who attends it, a skilful mechanick, familiar with the working of steam engines, has informed me that it had run six months without being repacked, and that he opened it rather from prudential considerations, than from any indication of its being necessary. On examination he found all its parts in remarkably good order, and that the engine would have continued to act much longer with perfect safety. This is an advantage, which they who are obliged to repack every month or six weeks, will know how to appreciate. From this, it appears, my early doubts were not well founded. I thought the Pendulum Engine would have a superiority in connecting the piston-rod immediately with the crank. The pitmans, parallel movements, and side guiding bars with slide boxes, are thereby superseded, and by diminishing the number of moving parts, without increasing the velocity or extent of any of the remaining rubbing surfaces, the friction must be reduced. The movement of the valves can be very simply effected by the oscillation of the cylinder so as to dispense with rods, eccentricks, and other expensive appendages. While the Pendulum Engine retains all that is essential to power, it is very much simplified in its mere mechanical construction, and is consequently an improvement. It is, I conceive, well adapted to boats, and in an especial manner to railways; but you know the difficulty of introducing novelties. An inventor has innumerable obstacles to overcome; he has to be long exposed to disappointment, opposition, and obloquy, before he can hope for success. Experience is the only test by which the publick will be ultimately influenced, and Mr. Lester has the gratification of knowing that experience has thus far decided in his favor.

With much regard,

Your friend and serv't.

RICHARD D. HARRIS.

WILLARD PHILLIPS, Esq. Boston.

This is to certify that I have erected and put in operation, at the Woollen Manufactory of Benjamin Buzzey, Esq. in Dedham, a Pendulum Steam Engine, by Ebenezer A. Lester, of Boston, on or about the first day of June, 1828. It has been in operation daily since that time, and has given full and complete satisfaction, being simple in its construction, easily attended, and not liable to be disordered.

GEO. H. KUHN.

Boston, Oct 1, 1829.

This is to certify that I am the superintendent of the Woollen Manufactory of Benjamin Buzzey, Esq. in Dedham, and that the Pendulum Engine erected there by Ebenezer A. Lester, of Boston, has been under my direction from about the first day of July, 1828. It has fully answered my expectations; being simple in its construction, easily attended, (not requiring a professed engineer,) and from the test thus far had, it does not appear to be more liable to wear, either in the cylinder, piston, or piston-rod, than other engines. It does not require packing oftener than three or four times a year.

I further certify, that in the month of July last, I was informed that this plan of engine was liable to wear the cylinder oval, and also the piston and piston-rod untrue, in consequence of which, I was induced to cause the engine in this factory to be examined, when it was found that the cylinder, piston, and piston-rod, were not worn in the least, out of round, but on the contrary, were in excellent order, smooth, true, and fair.

THOMAS BARROWS.

Dedham, Oct. 2d, 1829.

The engine referred to in the foregoing certificates, has been in operation daily, (Sundays excepted) up to this time. The facts above stated, are confirmed by further experience, and we continue to be well satisfied with the engine. The packing has been entirely renewed only three times.

June 29th, 1830, GEO. H. KUHN.
THOMAS BARROWS.

Extract of a Letter, from the Rev. Enoch Burt, of Manchester, Conn. dated, June 11, 1830.

It is now six months since I have had your Pendulum Engine in operation. It works well. From a practical as well as scientifick acquaintance with the various engines now in use, I at the first examination (viz. at the Dry Dock in Charlestown,) pronounced it in my own mind vastly superior to any other plan, and from operating it for six months (during which time it has never been repacked) in my manufactory, I am fully confirmed in my opinion of its superiority; it is, you know, only a 4 1-2 inch calibre and 18 inches stroke, and I run it but 35 revolutions per minute: (it would be advisable to run it much quicker, but this speed is best for my work) and with steam at 25 lbs. per inch, it drives my fulling mill, calender, shearing and drying machines and raises the water for the works by a pump of 4 inch calibre and 9 inches stroke, from a well 25 feet deep. I have run it three days with one cord of 2 feet wood, (oak)* which is sufficient. The simplicity of it is admirable. It exhibits all its parts in operation at a single view. I have no trouble in keeping it tight and in order—and I do not hesitate to say that it will, with a given quantity of steam, produce an effect 20 per cent. greater than can be produced in one of the same size stationary cylinder. This arises from the great diminution of friction, by the direct application of the power to the crank. It runs perfectly smooth—no noise—and with proper attention no way liable to get out of order. Those who want steam power, need only make themselves acquainted with the Pendulum Engine to give it at once a decided preference to every other kind now in use—for it only wants to be known to be preferred, and this is the engine that is fitted from its construction (and the only one) for railroads. I need not wish you great success in introducing it; the intrinsick excellency of the invention must insure it. If my opinion is of any service to you in forwarding its introduction, you are at liberty to make what use of it you think proper.

Yours, &c. E. BURT.

Mr. E. A. LESTER.

* That is, half a cord of the usual length of 4 feet.

NOTE—The cylinder of this engine is 10 in-

ches calibre and 28 inches stroke, operates with steam from 60 to 70 pounds per inch, 60 revolutions per minute, with 2 cylinder boilers of 2 feet 8 inches diameter, and twenty feet in length each.

Such is the result of experience, in respect to this engine; certificates of similar import might have been added, respecting other Pendulum Engines that have been put up, but they were deemed unnecessary. The engines, above referred to, have been so thoroughly tested and proved, that the result, in respect to the principles of construction and practical advantages of the machine, are deemed to be as conclusive, as if a hundred of them had been in operation for ever so long a time; since if it were constructed upon erroneous principles, *one* could not be made to operate successfully and advantageously, and the constant operation of *one* for two years, is certainly sufficient to develope its properties, and show the objections, if any, to which the principle is liable. It was deemed the less necessary to add any further certificates, as no fact can be stated in relation to any engine of this description, which has ever been put into operation, that can, in the slightest degree, detract from, or tend to throw the least doubt upon, the results of the operation of the engines particularly referred to in these statements.

The following restrictions upon Mr. Lester's Engine, has been sent us by a scientifick correspondent. As our pages are always open for the free discussion of the merits or demerits of inventions, we freely give it room. We must be allowed to say, however, that we do not think our correspondent's objections very serious, either in detail, or the whole. Mr. Lester's application of steam, and machinery, is certainly one of great merit, and one, perhaps, in which as few objections can be brought as in any other—this, we think, our correspondent will admit himself.

Comment on Mr. Lester's Vindication of his Pendulum Steam Engine.

In Mr. Lester's account of his pendulum engine, he has advanced some reasonings which are not *perfectly correct.* These reasonings or assertions having emanated from such high authority, and having place in this useful Magazine, may mislead some juvenile readers, if they be not refuted. I, therefore, propose to show that he has committed some oversights; though I have not time or inclination to scan every sentence. I wish to have it distinctly understood, that my object is, not to oppose the introduction of the pendulum engine, but to protect those who are not versed in mechanicks, from error: for I do not think the pendulum engine is of a very bad principle, nor do I think it much better than the common engines.

I will here digress a little from my subject, as I think circumstances require it. I do not pretend that Mr. Lester's account of his engine ought not to have been printed in this Magazine: I think some account of it should have been, as such *media* are the best means by which mechanicks can learn what improvements are making in their arts. In works of this kind, some erroneous principles will unavoidably find admission; but they may do no great mischief, as one of the prerogatives of such works is, that when important and wrong principles are advanced, they commonly are confuted. But if a reader meets with false assertions in other books, he is liable to be misled if he does not thoroughly understand the subject. Let us return to our subject.

What I have here written will be as well understood by reading at the same time Mr. L.'s account in the last number of the Magazine, as if I had quoted the passages at length. Mr. L. asserts as follows: "I will here make a suggestion respecting the estimate of the *power* of an engine, in regard to which, there is a great deal of obscurity and uncertainty, both in contracts and in speculations on the subject. In estimating the power of an engine, for instance, as being equal to that of a certain number of horses," &c. I do not see that the suggestion which follows, is much needed: the term *horse power*, as applied to steam engines, is as definite as the term dollar, or pound. This horse power is equal to the raising of 33,000 pounds avoirdupois one foot per minute. But it should be observed that this is a greater force than a horse of ordinary strength should exert, for any considerable time. Mr. L. may have known of some person trying to calculate the power of a steam engine, who knew not how to do it; but this could not be for the want of rules, as there probably never was a treatise published on steam engines which did not contain some rule for this purpose.

Mr. L. says, "It is a popular error, also, not to distinguish sufficiently the engine from the boiler or generator, which is, in fact, as distinct from the engine, as the strength of the mechanick is from the tool with which he works." I believe that all

authors, or at least, all good authors, who have written on steam engines, call the boiler a part of the engine; it is called so in Patterson's edition of Ferguson's Lectures on Mechanicks, page 166, vol. 1; also, in Hutton's Mathematical and Philosophical Dictionary, page 520, vol. 2. I am aware that this distinction has been made by some workmen who knew little of the subject. But this should not have made a scientifick gentleman suppose that all language which varies from this usage erroneous.

In another place he says: "during all the time when the power acts upon the crank, it acts at an angle: constantly varying, but still at an angle. Every practical engineer knows very well, as does every theoretical mechanick, as well as every man of ordinary observation, though he be neither a practical or theoretical mechanick, that this circumstance must occasion a loss of power," &c. From this, and what follows, it is plain that he means that there is a loss of power, distinct from that of friction. Mechanicks are very apt to err, in supposing that there is a loss of power in such cases, distinct from that of friction; though it can be demonstrated that there is no such loss, or that the same expenditure of power will produce an effect, excepting friction, equal to that which would be produced if the force acted in the direction in which the crank is moving. But as abstruse mathematical reasonings are not very acceptable to most readers, I prefer quoting a passage from the highest authority on this subject. Tredgold, in his treatise on the Steam Engine, page 236, after describing a method of connecting the piston-rod with the crank, speaks of it as follows: "When the fly is of sufficient power, the whole loss of force in this combination is simply the friction produced by oblique action, and is less in proportion as the connecting-rod is longer; provided the stress from the weight be not materially increased.

The whole increase of stress required for converting a reciprocating into a rotary motion cannot double the friction on the crank axis in any case, and as double this friction never amounts to a tenth part of the power of an engine, there is no reason to hope for an equal degree either of economy or simplicity, by using the rotary action of steam." Mr. L. having taken this false principle for his guide, has necessarily drawn wrong conclusions. It seems that from his mistaken notion, that steam is used to a greater advantage in the pendulum engine, than in common engines He has not made his boilers large enough to supply a sufficient quantity of steam to produce the power at which he rates his engines.

Mr. L. says: "If it should be established, that the weight and surfaces being given, the friction will be as the *time* without regard to the velocity," &c. That the friction of machinery is very nearly the same whether its motion be quick or slow, is a law well known to scientifick mechanicks. An account of experiments proving this may be seen at page 230, vol. 2, of Nicholson's Operative Mechanick; or in the American edition of the Supplement of Dr. Gleig's Encyclopedia, under the article Friction. Many have misunderstood, or drawn a wrong inference from the expression, *the friction is the same, whatever be the velocity.* Perhaps a better phrase for expressing this property, is, *the friction of one hard substance rubbing on another is a nearly uniform retarding force.* I can illustrate this best by an example: supposing a carriage placed on a railway, having a weight attached to it so as to pull the carriage in the direction of the railway, and a very small motion be given to the carriage as one foot per minute, and the weight be so adjusted as to be just sufficient to keep the carriage moving with this small velocity; then if a greater velocity, as ten feet per minute, be given the carriage, the same weight will keep the carriage moving uniformly at this second velocity. In the second case the weight descends decuple as far in a minute as in the first case, so the weight must descend just as far to move the carriage a given distance, whatever be the carriage's velocity. Therefore, there is the same expenditure of power in a carriage's moving a given distance on a rail road, whether it move swift or slow. This principle is commonly said to be *exact*, though in most cases the friction differs a *very little* from it. The law of friction in most machinery is nearly the same.

Mr. L. has, through the whole of this composition, confounded gravity with inertia; or he means something by the word *gravity* which I cannot comprehend; as in the following: "Every circumstance in the effect of gravity accords with and facilitates the operation of the pendulum engine." The gravity, (using the term in the sense in which it has always before been used in mechanicks,) or weight of the revolving parts of the engine, increases the friction on their axes, without, in anywise, facilitating its operation. I admit, that in a vertical

wheel, the gravity of the side which is descending does tend to turn it the way it is turning, but the gravity of the opposite side, which is ascending, tends to turn it the other way just as much; the weight of both sides taken together, produces a pressure on its axis, which necessarily creates friction. The definitions of these terms as given in Hutton's Mathematical and Philosophical Dictionary, are as follows: "GRAVITY, in mechanicks, denotes the conatus or tendency of bodies towards the centre of the earth. VIS inertial, or power of inactivity, is defined by Newton to be a power implanted in all matter, by which it resists any change endeavoured to be made in its state, that is, by which it becomes difficult to alter its state, either of rest or motion." The inertia of any body, as far as is known, is always the same in all places and conditions. But the gravity of a body is different in different places. I do not see how a man can understand mechanicks, without a knowledge of these two properties of matter. If Mr. L. meant inertia instead of gravity, in the passage last quoted, it would be little nearer the truth; as the inertia of some parts of the machine facilitate its operation, and the inertia of other parts opposes it a little.

He next speaks of the effects which the motion of the piston and piston-rod, up and down in the cylinder, will produce on the swinging of the cylinder; piston, and piston-rod, considered as a pendulum. He asserts that when the piston is near the upper end of the cylinder the pendulum is shorter and consequently that it will vibrate faster than when the piston is nearer the lower end of the cylinder. It should be observed that in a pendulum which has its axis below its highest part, as in the cylinder of the pendulum engine, that by raising a part of the pendule, the distance between the centre of oscillation and its axis may be increased; in this case it would have the effect of a longer pendulum so as to vibrate slower. When the weight, distance, and position of each part of the cylinder, piston, and piston-rod, are known, and the piston and rod confined to any one place, that is, not allowed to move up and down in the cylinder, the durations of its oscillations, considered merely as a pendule, are easily calculated. But if the piston move up and down in the cylinder while it vibrates, the calculation will be very difficult. The oscillations of a pendulum are produced by three forces, viz. gravity, inertia, and the force exerted by the rod or string which suspends the weight. If the last mentioned force be wanting, it cannot act as a pendulum. If it be only diminished, as by letting the weight drop, though still exerting a little force on the string, it would oscillate slower.

Dr. Hutton investigated this matter: but Prof. Adrain detected an error in his reasoning, and also gave a course of reasoning on the subject; which I deem to be likewise erroneous. I think this is one of the necessary præcognita in investigating the motions of the pendulum engine, which I deem far more implex than the question, which baffled those great mathematicians. When the steam is forcing the piston of the pendulum engine down, one of the forces which produces oscillation in the common pendule, does not act upon the piston and piston-rod; and further, there is a great force exerted on them in the opposite direction: when the piston is rising, the great force acts in the other direction. Though it may be beyond my humble capacity to determine the exact effect of this force on the vibrations of a pendulum, yet I believe I can demonstrate, in a future communication, that there is, necessarily, a small expenditure of power in the pendulum engine, in producing this motion, and that the cylinder has, in a small degree, a tendency to be worn elliptical. U. A. B.

PRACTICAL SCIENCE.

The practical results of the progress of physicks, chymistry, and mechanicks, are of the most marvellous kind, and to make them all distinct would require a comparison of ancient and modern dates; ships that were moved by human labour in the ancient world are transported by the winds; and a piece of steel, touched by the magnet, points to the mariner his unerring course from the old to the new world; and by the exertions of one man of genius, and by the resources of chymistry, a power which, by the old philosophers could hardly have been imagined, has been generated and applied to almost all the machinery of active life: the steam engine not only performs the labour of horses, but of man, by combinations which appear almost possessed of intelligence; wagons are moved by it; constructions made, vessels caused to perform voyages in opposition to wind and tide, and a power placed in human hands which seems almost unlimited. To these novel and still extending improvements may be added others, which, though of a secondary

kind, yet materially affect the comforts of life—the collection from fossil materials of the elements of combustion, and applying them so as to illuminate, by a single operation, houses, streets, and even cities. If you look to the results of chymical arts, you will find new substances of the most extraordinary nature applied to various novel purposes; you will find a few experiments in electricity leading to the marvellous results of disarming the thunder cloud of its terrors, and you will see new instruments created by human ingenuity, possessing the same powers as the electrical organs of living animals. To whatever part of the vision of modern times you cast your eyes, you will find marks of superiority and improvement, and I wish to impress upon you the conviction, that the results of intellectual labour or scientifick genius, are permanent and incapable of being lost. Monarchs change their plans, governments their objects, a fleet or an army affect their purposes, and then pass away; but a piece of steel touched by the magnet, preserves its character forever, and secures to man the dominion of the trackless ocean. A new period of society may send armies from the shores of the Baltick to those of the Euxine, and the empires of the followers of Mahomet may be broken in pieces by a northern people, and the dominion of the Britons in Asia may share the same fate as that of Tamerlane or Zengiskhan; but the steam boat which ascends the Mississippi or the St. Lawrence will be continued to be used, and will carry the civilization of an improved people into the deserts of North America, and into the wilds of Canada.—(Sir Humphrey Davy.)

COMMUNICATION.] FOR THE JOURNAL.

RAILWAYS AND CANALS.

In my last I attempted a rapid glance at the principal measures for Internal Improvement in the Western States and Louisiana, Georgia and South Carolina.

In North Carolina a canal 7 miles in length was constructed some years since around the falls of the Roanoke River.

The Dismal Swamp canal is partly in North Carolina and partly in Virginia, connecting the waters of Albemarle Sound with those of the Chesapeake Bay. It is 23⅜ miles long, minimum breadth 40 feet, with recesses every quarter of a mile 60 feet for turn out stations. Minimum depth 6½ feet.

The locks are made to conform to those of the Delaware and Chesapeake canal, and both are designed for the accommodation of the coasting trade. There is also a lateral canal, 7 miles, 20 feet wide, and 4½ deep. And another, or rather a feeder, to Lake Drummond, 18 feet wide and 4 deep. This canal has been in operation about one year. Income from tolls, in May, June and July last, 8,000 dollars.

The State of Virginia own 256 shares, United States 800, and individuals 384.

Boats are propelled by the men with poles, in which way they pass through in about 1¾ days. A steam tow boat with paddles in the stern has recently been introduced, with what success I have not learned. The general benefits of this canal anticipated by its projectors have thus far been fully realized, especially in Norfolk.

In Virginia, a rail road is just now completed from Manchester to the coal mines, 13 miles.

A route has also been surveyed for a rail road from Petersburgh to the Roanoke river, 60 miles. About the first of August $200,000 was subscribed by the city of Petersburgh, and upwards of $100,000 by individuals of that place. The Dismal Swamp canal, already described, is partly within this State. The question as to the expediency and importance of introducing rail roads and canals has but recently been agitated in this great State, and as yet but little has been accomplished in this way.

The Chesapeake and Ohio canal commences at Georgetown, District of Columbia, and is to terminate at Pittsburgh, in Pennsylvania.—360 miles.

From Georgetown to Seneca, 22 miles, is finished, and it is expected to be finished to Harper's Ferry, near the junction of the Shenandoa and Potomack rivers, about 60 miles, during this season. The first two miles of this canal above Georgetown are 70 feet wide on the surface, and 7 feet deep. The next 2 miles 80 feet wide, 6 feet deep. Five miles from Georgetown the canal is so planned that a branch may be conducted to Alexandria, another to Baltimore, and another to the Navy Yard. The remaining distance to the point of rocks, 44 miles, width 60 feet, depth 6.

A petition has been presented to the President, signed by seventy-eight members of Congress, for the aid of 1000 troops to construct the proposed tunnel through the summit of the Allegany ridge. This tunnel is to be 4 miles long, and will overcome a rise and fall of 1700 feet. Should this be accomplished, it will be the longest tunnel in the world. The distance from this tunnel

to the navigable waters of the Potomack is 31 miles, and 70 from the Monongahela.

A highly commendable zeal for the advancement of internal improvement has been manifested in Maryland.

The Baltimore and Ohio rail road was commenced two years since. The first 13 miles, to Ellicott's Mills is finished with a double track. A single track is laid down 12 miles further, and the whole line to the valley of the Potomack, (upwards of 60 miles,) is in progress and expected to be completed by the end of the ensuing year, and 50 miles per annum, until the whole is completed.

The actual cost for gradation and masonry, of the first 13 miles was more than $46,000 per mile. It was expected that this would be the most expensive part of the route, but nothing like what has been incurred.

In consequence of a change in the location of this part of the road a very great increase in the amount of excavation and embankment was rendered necessary.—Substituting stone for wooden bridges, and finishing them in a style of elegance altogether incompatible with the dictates of that economy which is indispensable to the successful prosecution of a work of this kind, together with a want of concert and agreement among the directors and engineers are the principal causes of this increased expense.

The single work called the Patterson viaduct has 10,000 perches of masonry in it. It is built of hewn granite blocks of from one to seven tons each. The height from the water to the arches is 30 feet. It may, and in fact is, said to be "truly a great work —an immense structure—creditable to the enterprise and publick spirit of the company, and to the skill of the engineers." All this, however, may with equal truth be said of the mausoleums, obelisks and pyramids of Egypt. But after all, it has more of sound than substance in it.

Directors and engineers of works of this kind ought to feel that every dollar expended for show and elegance is worse than lost; for it goes directly to retard or prevent the completion of their own enterprises, and to discourage all others of a similar kind.

The interest of the money expended on this viaduct would probably be sufficient to erect a wooden bridge every year, which would last, almost without expense, ten or fifteen years.

As the immense expense of the first 13 miles of this road has had a great effect in damping the zeal and ardor in relation to similar enterprises in other parts of the Union, and particularly in this, I subjoin a few extracts from a recent report of the directors in relation to other parts of this road.

The whole cost of masonry and gradation from Baltimore to Ellicott's mills was $46,496 per mile.

The next division, extending to the forks of the Petapsco, and now nearly completed, it is ascertained, will cost $10,022 per mile.

The third division, to Parr's Spring Ridge, will be but $7,001 per mile.

In fact it has been satisfactorily ascertained that the gradation and masonry of the first 10 miles have cost more than the next 56 miles will cost.

Great confidence is still felt by those most competent to judge correctly in relation to this enterprise, that this road will yet be completed at an expense within the original estimate. Say $22,000 per mile for a double track.

The Baltimore and Susquehanna rail road was commenced this season and considerable progress has been made. This road is to extend from Baltimore to York-Haven, on the Susquehanna, a distance of about 60 miles.

Port Deposit canal, 10 miles long, extending up the Susquehanna from Port Deposit. It has been in operation some years and was constructed for the accommodation of the boat navigation of that river.

The only measure of importance for internal improvement within the limits of Delaware is the Chesapeake and Delaware canal, which unites the waters of those two great bays, and is intended for the accommodation of the coasting trade. It is 60 feet wide and 10 feet deep. Commenced in 1823, and finished in 1829—cost $150-000 per mile, and is 14 miles long. This is a valuable improvement. Its trade and income are rapidly increasing, but its stock is still below par. Its future benefits to Philadelphia and Baltimore will at all times be great—in time of war incalculable.

The Morris canal, in New Jersey, is an undertaking of considerable magnitude. It is 100 miles long, commencing at Newark, and extending across the State by a very circuitous route, to Easton, in Pennsylvania, where it connects with the Lehigh canal—has 1400 feet lockage, and several inclined planes, which, from experiments already made, are supposed to be an improvement in canaling. This canal is expected to be finished this season.

A company has recently been incorporated for the construction of a canal from Trenton to New Brunswick, which is to unite the waters of the Delaware river with Raritan bay. It is uncertain whether this canal will be constructed of sufficient dimensions for the accommodation of sloop navigation or not.

A company has been formed for the construction of a rail road from South Amboy, on the Raritan bay, to the Delaware, opposite Philadelphia. The stock is all taken up, and is already above par. It is to pass up the Delaware as far as Bordentown, and then across the State of New Jersey to Amboy. As this is on the line of an immense travel, there can be but little doubt of its being productive stock as well as a valuable publick improvement.

The following table presents a tolerably correct account of the various canals in the union.

States.	Canals.	Miles.	Cost pr. m.
Maine.	Oxford	30	
Mass.	Middlesex	28	$20,000
"	Hadley	3	
"	Montague	3	
"	Pawtucket	2	
R. Island.	Blackstone	45	13,000
Conn.	Farmington	87	11,000
N. York.	Erie	363	20,000
"	Champlain	63	
"	Oswego	40	
"	Cayuga and Seneca	20	
"	Hudson and Delaware	81	16,000
N. Jersey.	Morris	100	
Penn.	Schuylkill Navigation	108	21,000
"	Union	83	20,000
"	Lackawaxen	43	20,000
"	Lehigh	46	25,000
"	Conostoga Navigation	18	4,000
"	State canals, about	420	23,000
Delaware.	Del. and Chesapeake	14	150,000
Maryland.	Port Deposit	10	
"	Chesapeake and Ohio	60	
Ohio.	Ohio	306	11,200
"	Dayton	67	12,000
Georgia.	Ogeche and Altamaha	16	10,000
S.Carolina.	Winyaw	10	
"	Santee	30	
N.Carolina.	Dismal Swamp	23	
"	Lake Drummond	7	
	Total, 2126 miles.		

All of which is in operation or expected to be in the course of this fall. And there is also in the different States, probably not less than 1000 miles more in progress, or on the point of commencement.

Rail ways having been but recently introduced, no very extensive work of the kind has yet been completed. There are the following

Rail Ways.	Miles.	Cost pr. mile.	Track.
Manchester	13		Single
Quincy	3	$11,000	Single
Mauch Chunk	9	3,050	Single
Schuylkill	13	7,000	Double
Mill Creek	4	3,500	Single
Mount Carbon	9	11,000	Double
Schuylkill Valley	10	5,500	Double
Lataral, intersecting, do	13	2,600	Single
West Branch,	15	10,000	Double
Laterals for do.	5	2,000	Single
Lackawaxen	16	12,000	including engines and other appendage.
	110		

In addition to which, the following are in progress.

Rail Ways.	Miles.	Estim'd cost pr. m.
Albany and Schenectady	18	
Camden and Amboy	65	
Columbia	84	$15,000
Allegany	38	25,000
Lakens Valley	16	
Little Schuylkill	18	
New Castle & French Town	16	
Petersburgh and Roanoke	60	
Baltimore and Ohio	340	22,000
Baltimore and Susquehanna	60	
Charleston and Hamburgh	150	6,500
Lexington and Ohio	80	
Detroit and Pontiac	25	
Louisiania	4	
	Total, 974 miles.	

The governments of Great Britain and the Canadas are actively engaged in works of internal improvement on the other side of the Lakes.

Welland canal is completed and in operation. Extent 36 miles. Rapid progress is also making towards the completion of the Rideau Canal. This is 150 miles in length.

Lachine canal is completed, and one of the most beautiful and perfect structures of the kind on this side the Atlantic. All these canals are for sloop navigation, and when the Rideau shall have been completed, vessels of 8 feet draught may pass from the mouth of the river St. Lawrence to the shores of Lake Superior, not less, probably, than 2000 miles. It is stated that transportation between Lake Erie and New York is 31 cents per cwt. less by the way of the Welland and Oswego canals than by the Erie. If this be a fact, a rail road from Ogdensburg to Boston, (provided a rail road affords only equal facilities for transportation with a canal,) must maintain a successful competition with the Erie canal and North river, for the immense trade of the West.

MIDDLESEX.

[In the last communication of Middlesex, a transposition of paragraphs occurred. Page 244, col. 2d, the paragraphs commencing " This en-

terprise is undertaken" and "This road is for the locomotive engine," should have been the terminating paragraphs of the whole article.]

COUNT RUMFORD.

Extract from a Biographical Memoir of *Sir Benjamin Thomson*, Count Rumford; by Baron Cuvier. Read to the Institute of France. From the Edinburgh New Philosophical Journal.

Benjamin Thomson, more commonly known by his German title of Count Rumford,* was born in 1753, in the English Colonies of North America, at a place then called Rumford, and at present Concord, belonging to the State of New Hampshire. His family was of English origin, and cultivated some lands there; and he himself has said that he should probably have remained in the humble condition of his parents, had he not in childhood been deprived of the little means they were able to bequeath to him. Thus, like many other literary characters, it was to early misfortune that he owed his subsequent good fortune and celebrity.

His father died young. His mother having married again, he was separated from her by his stepfather; and his grandfather, from whom alone he had any thing to expect, had disposed of all that he possessed in favor of a younger son, and left him in almost complete destitution.

There is nothing more calculated to induce a premature development of intellect than such a condition as this. The young Thomson attached himself to a clergyman of learning, who undertook to prepare him for the mercantile profession, by giving him a smattering of mathematicks. But the good minister also spoke sometimes to him of astronomy, and his lessons in that science benefited his pupil more than he had foreseen.

The young man brought him one day the plan of an eclipse which he had traced according to a method which had suggested itself to him on reflecting upon his master's discourses. It was found to be singularly accurate, and this success induced him to abandon all for science. * * * * * * * * * * * * Every one knows that the object of his finest experiments was the nature of heat and light, as well as the laws of their propagation; and in this, what interested him was, to know how to feed, clothe, warm, and light with economy, a great assemblage of men. He first engaged in comparing the heat of different kinds of clothes. This, as is well known, is not an absolute heat, and we only mean by it the property of retaining that which is generated by our bodies, and of preventing its dissipation. Count Rumford enveloped thermometers raised to a higher temperature than the air with various substances, and observed the time they took in returning to a state of equilibrium. He arrived at this general result, that the principal retainer of heat is the air between the fibres of substances, and that these substances furnish clothes so much the warmer, the more they retain the air heated by the body. It is thus, and it will not fail to be remarked, that nature has taken care to clothe the animals of cold countries.

Passing then to the examination of the most effectual means of economising fuel, he saw in his experiments that flame in the open air gave little heat, especially when it was not rapidly agitated, and did not strike vertically the bottom of the vessel. He also observed that the vapor of water conduced very little to heat when it was not in motion. Chance gave him the key of these phenomena, and opened up to him a new path of inquiry. Casting his eyes on the coloured liquor of a thermometer, which was cooling in the sun, he perceived in it a constant motion, which continued until the thermometer had fallen to the surrounding temperature. Some powders which he diffused in liquids of the same specifick gravity, were also agitated whenever the temperature of the liquid changed, a circumstance which announced currents in the liquid itself. Count Rumford came to think that it was precisely by this transportation of molecules

* At the commencement of the American revolution, Mr. Thomson took an active part in favor of the royalists, and was sent out to England on a mission of some importance, he made a favorable impression on lord George Sackville then Secretary of State for the American department. From this era his good fortune may be said to have commenced; he experienced many favours from the royal government, and at length received the order of knighthood. Shortly after this he was sent on a mission to Bavaria. The elector, Charles Theodore, granted him the most marked favor: he made him successively his aid-de-camp, his chamberlain, member of his council of state, and lieutenant-general of his armies. He procured for him the decorations of the two orders of Poland, because the statutes of those of Bavaria did not then permit his admission to them. Lastly, in the interval between the death of the Emperor Joseph and the coronation of Leopold II., the elector took advantage of the right which his functions, as vicar of the empire, gave him, to raise Sir Benjamin to the dignity of Count, by the name of the district of New Hampshire in which he was born.

that the heat was distributed in the liquids, which by themselves would have allowed very little calorick to pass. Thus, when the heating commences below, the warm molecules, becoming lighter, ascend, and the cold molecules are precipitated to the bottom to be heated. This he verified by direct and ingenious experiments. So long as only the upper part of the column of liquid was heated, the lower did not in any degree partake of the heat. A piece of red hot iron plunged in oil to a short distance from a bit of ice which lay at the bottom, did not melt a particle of it. A bit of ice kept under boiling water was two hours in melting, while at the surface it melted in three minutes. Whenever the internal motion of a liquid was arrested by the interposition of some non-conducting substance, the cooling or heating, in a word, the equilibrium, was retarded in it. Thus feathers or hair would produce the same effects in water as in air.

As it is known that fresh water is at its maximum of density at seven degrees above the freezing point, it becomes lighter a little before freezing. It is for this reason that ice always forms at the surface, and that once formed, it preserves the water which it covers. Count Rumford found in this property the means by which nature preserves a little fluidity and life in the countries of the north; for if the communication of heat and cold took place in fluids as in solids, or only in fresh water as in other liquids, the streams and lakes would quickly be frozen to the bottom.

Snow, on account of the air which is mingled with it, was in his eyes, the mantle which covers the earth in winter, and prevents it from losing all its heat. He saw in all this distinct precautions of Providence. He saw the same in the property which salt water possesses, the reverse of that of fresh water, by which, at all degrees of temperature, its molecules are precipitated when they are cooled; so that the ocean, being always temperate at its surface, softens the rigour of the winters along the shores, and warms again by its currents, the polar climates, at the same time that it cools those of the equator.

The interest of Count Rumford's observations, therefore, extended, in some measure, to the whole economy of nature in our globe, and perhaps he made as many cases of those relations to them which he perceived in general philosophy, as of their utility in publick and private economy.

Their mere announcement must have made my hearers anticipate this utility; and, besides, there is no one who does not know their effects from experience. It was by a regular application to these discoveries, that Count Rumford constructed fire-places, furnaces, and caldrons of new forms, which, from the hall to the kitchen and the workshop, have reduced the consumption of fuel by more than a half.

When we fancy to ourselves those enormous chimneys of our ancestors, in which whole trees were burnt, and which almost all smoked, we are astonished that the simple and sure improvement of Count Rumford was not sooner devised. But there must be some difficulty concealed in all those things which are found out so late, and which we call so simple when once they are discovered.

The improvements which Count Rumford made in the construction of kitchens, will have a more important, although a somewhat more tardy result, because somewhat more firm foundations must be laid for their first establishment. The unfortunate cook himself, at present half roasted by the heat of his fire, will be enabled to operate calmly in a mild atmosphere, with an economy of three-fourths for fuel, and of one half for time: and Count Rumford did not consider as of small importance this ease procured for those who prepare our food. As the same quantity of original matter furnishes a much greater or a much smaller quantity of nutrition, according as it is prepared, he looked on the art of cookery as equally interesting with that of agriculture. He did not confine himself to the art of cooking food at little expense, but also bestowed much attention on that of composing it. He discovered, for example, that the water which is incorporated with food becomes itself, by this mixture, a nutritive matter; and he tried, of all the alimentary substances, to find out that which nourishes most and at the smallest expense. He even made a study of the pleasure of eating, on which he wrote an express dissertation; not assuredly for himself, for his moderation was excessive, but in order also to discover the economical means of increasing and prolonging it, because he saw in it an intention of nature to excite the organs which are to concur in digestion.

It was by thus judiciously combining the choice of substances, with all possible economy in the art of preparing them, that he was enabled to support man at so little cost, and that, in all civilized countries, his

name is now connected with the most efficacious aids that industry can receive. This honour much excels those which have been decreed to the Apiciuses of ancient and modern times; I would even venture to say, to many men who have been celebrated for discoveries of a higher order.

In one of his establishments at Munich, three women were sufficient to prepare a dinner for a thousand persons, and they burnt only ninepence worth of fuel. The kitchen which he constructed in the Hopital de la Pieta at Verona, is still more perfect, there being burnt in it only the eighth part of the wood which was formerly consumed.

But it was in the employment of steam for heating, that Count Rumford, so to speak, surpassed himself. It is known that water kept in a vessel which it is unable to burst, acquires an enormous heat. Its vapor, at the moment when it is let loose, carries this heat wherever it is directed. Baths and apartments are thus heated with wonderful quickness. Applied to soapworks, and especially to distilleries, this method has already enriched several manufacturers of our southern departments; and in the countries where new discoveries are more slowly adopted, it has offered immense advantages. The brew-houses and distilleries of England are heated in this way. In them a single small copper caldron boils ten large wooden vats.

Count Rumford went so far in his improvements as even to economise all the heat of the smoke, which he only allowed to issue from his apparatus after it had become almost perfectly cold. A person justly celebrated for the elegance of his mind, said to him that he would soon cook his dinner with his neighbor's smoke. But it was not for himself that he sought economy. His varied and often repeated experiments, on the contrary, cost him much, and it was only by dint of lavishing his money, that he taught others to save theirs.

He made nearly as many researches on light as on heat, and among his results, the following observations are principally worthy of notice; that flame is always perfectly transparent and permeable to the light of any other flame; that the quantity of light is not in proportion to that of the heat, and that it does not depend, like the latter, upon the quantity of matter burnt, but rather upon the vivacity of the combustion. By combining these two observations, he invented a lamp with several parallel wicks, the flames of which mutually exciting each other, without allowing any of the rays to be lost, are capable of producing an unlimited mass of light. It is said that when it was lighted at Auteuil, it so dazzled the lamp-maker who had constructed it, that the poor man was unable to find his way home, and was obliged to pass the night in the wood of Boulogne.

I deem it superfluous to mention how he varied and adapted to all sorts of uses the different instruments that are employed for lighting. The Rumford lamps are not less diffused nor less popular than the chimneys and soups of the same name. This is a true character of a good invention.

He determined, by physical experiments, the rules that render the oppositions of color agreeable. Few fine ladies imagine the choice of a border, or of the embroidery of a ribbon, depends on the immutable laws of Nature, and yet such is the fact. When one looks steadily for some time at a spot of a certain color on a white ground, it appears bordered with a different color, which, however, is always the same with relation to that of the spot. This is what is called the complementary color; and, for reasons which it were needless to develope here, the same two colors are always complementary to each other. It is by arranging them that harmony is produced, and the eye flattered in the most agreeable manner. Count Rumford, who did every thing by method, disposed, according to this rule, the colors of his furniture, and the pleasing effect of the whole was remarked by all who entered his apartments.

Continually struck, in all his labours, by the wonderful phenomena of heat and light, it was natural for him to attempt a general theory respecting these two great agents of nature. He considered them both as only effects of a vibratory motion impressed on the molecules of bodies, and he found a proof of this in the continual production of heat which takes place by friction. The boring of a brass gun, for example, putting water in a short time into a state of ebullition, and this ebullition lasting as long as the motion which produced it, he found it difficult to conceive how, in such a case, matter was disengaged, for it would require to be inexhaustible.

He moreover proved, better than any person, that heat has no weight. A phial of spirit of wine, and another of water, remained in equilibrium after the congelation of the latter, although it had lost by this,

calorick enough to raise the same weight of gold to a white heat.

He invented two singularly ingenious instruments. The one, which is a new Calorimeter, serves to measure the quantity of heat produced by the combustion of a body. It is a box filled with a given quantity of water, through which the product of the combustion is made to pass by a serpentine tube; and the heat of this product transmitted to the water, raises it a determinate number of degrees, which serves as a basis to the calculations. The manner in which he prevents the external heat from altering his experiment, is very simple and ingenious. He commences the operation at some degrees below that heat, and terminates it at as many degrees above it. The external air resumes, during the second half, precisely what it had given out during the first. The other instrument serves to disclose the slightest differences in the temperature of bodies, or in the facility of its transmission. It consists of two glass balls filled with air, connected by a tube, in the middle of which is a bubble of colored spirit of wine. The smallest increase of heat in one of the balls drives the bubble toward the other. This instrument chiefly, which he named a Thermoscope, made known to him the varied and powerful influence of different surfaces over the transmission of heat, and also pointed out to him numerous methods of retarding or accelerating, heating or cooling at will.

These two last kinds of researches, and those which have reference to illumination, ought to interest us more particularly, because he had made them after he had fixed his residence at Paris, and taken an active part in all our occupations. He considered them as his contributions in quality of a member of the Institute.

DAMPS.

The last No. (4th.) of the Americana Encyclopædia contains the following interesting article under the head of Damps; in which the reader will find a description of Sir Humphrey Davy's safety-lamp.

Damps are certain deleterious gases which are extricated in mines. They are distinguished by miners under the names of *choke-damp* and *fire-damp*. The former is found in the deepest parts of mines. It extinguishes candles, and often proves fatal when it has been suffered to accumulate in large quantities. It consists for the most part of carbonick acid gas. The fire-damp which prevails almost exclusively in coal mines, is a mixture of light carbureted hydrogen and atmospherick air, which explodes with tremendous violence whenever it comes in contact with flame. The injuries which formerly occurred so frequently, both to the machinery and the lives of miners, arising from the fire-damp, are now almost completely obviated by the fine invention of sir Humphrey Davy, the safety-lamp. It consists of a cylinder of wire gauze, about four inches in diameter and a foot in length, having a double top, securely fastened by doubling over to a brass rim, which screws on to the lamp itself below. The whole of the wire gauze is protected, and rendered convenient for carrying, by a triangular wire frame, and a ring at the top. The wire gauze is made either of iron or copper, the wire being at least one thirtieth of an inch in diameter, and woven together so as to leave 625 apertures in a square inch. The body of the lamp is of riveted copper, or of massy cast brass or cast iron, the screws fitting so completely as to leave no aperture into the body of the lamp. When the lamp is lighted, it affords the miner all the light which he requires, and renders him perfectly secure, even though entirely enveloped with the explosive mixture, which, with an ordinary light, would immediately prove fatal. The first effect of the fire-damp atmosphere is to increase the length and size of the flame. When the carbureted hydrogen forms as much as one twelfth of the volume of the air, the gauze cylinder becomes filled with a feeble blue flame, but the flame of the wick appears burning brightly within the blue flame, and the light of the wick augments until the inflammable gas increases to one sixth or one fifth, when it is lost in the flame of the fire-damp, which now fills the cylinder with a pretty strong light. As long as this explosive mixture of gas exists in contact with the lamp, so long it will give light; and when it is extinguished, which happens when the foul air constitutes as much as one third of the volume of the atmosphere, the air is no longer proper for respiration; for though animal life will continue when flame is extinguished, yet it is always with suffering. A coil of platinum wire being fixed above the wick of the lamp, within the gauze cylinder, the metal continues to glow long after the lamp is extinguished, and affords a sufficient light to enable the miner to make his escape. The effect of the safety-lamp

is supposed to depend on the cooling agency of the wire gauze, exerted on the portion, of gas burning within the cylinder. Hence a lamp may be secure where there is no current of an explosive mixture to occasion its being strongly heated, and yet not safe when the current passes through it with great rapidity. But any atmosphere, however explosive, may be rendered harmless by increasing the cooling surface, which may be done either by diminishing the size of the apertures, or by increasing their depth, both of which are perfectly within the power of the manufacturer of the wire gauze.

It is stated in the Nashville Banner that a rail-road and car, upon a simple and ingenious plan, has been invented by two gentlemen of that place, and put in operation on a small scale, as an experiment. The following is the description given of it:—

"The rail, which is single, is fixed upon posts, or rather upon arms extending from posts, elevated a suitable distance from the ground, and the carriage is suspended beneath. Two small wheels, one behind the other, run upon the rail, and a wheel within the carriage is connected with one of them by a band, and is turned by the hand or other power by means of a crank, which impels the carriage with great ease and very considerable velocity. The advantages of the plan are simplicity and cheapness. Its chief disadvantage appears to be the oscillation or swinging motion of the carriage resulting from its being suspended in the centre from a single rail. It is thought that this inconvenience, which will of course be less on a straight road than on a circular one, can be somewhat remedied by small arms so placed as to touch the under side of the rail when the carriage leans either way too far, and that some other important improvements can yet be made in the construction of the whole machine.—The exercise of moving it by hand on a level road is not at all laborious."

A person accustomed to its management will impel the above car at the rate of 15 or 16 miles per hour; and the invention, it is remarked, if of no other value, is capable of affording a delightful recreation and healthy exercise.—(Baltimore American.)

From the Miners' Journal.

FORMATION OF MINERAL COAL.

A lecture on the formation of mineral coal was delivered in this place on Thursday evening last, by a Dr. W. B. Powell, of Kentucky, at which a numerous and respectable audience attended. The doctrine advanced by this gentleman is at variance with the generally received opinions on the subject, and to our uninformed judgment, is supported with some plausibility of reasoning. He claims to be the first who has ever attempted a regular and lucid exposition of the *mineral* derivative nature of coal. Much practical information, the result of close and attentive observation was introduced in the course of the evening, which imparted a deep interest to the otherwise speculative character of his discourse. We have not the means, nor do we pretend to furnish a full detail of the facts and reasoning advanced by the lecturer, but for the gratification of those who were denied the opportunity of attending, we present the following brief outlines:—

He first maintains that vegetable impressions are not indispensably necessary to, or unavoidably connected with coal formations.

In the second place he contends that it is physically impossible for such an amount of coal, as we find to exist, to have been produced by vegetable matter, under any, or all of the circumstances contended for. He reasons that upon the old theory of vegetable origin, a bed of coal must have been formed annually, for the vegetable matter produced in each season would unavoidably be covered in the spring season by diluvium from the surrounding country, and that a bed of coal to be formed in so short a time is not contended for by the vegetable theorists.

In the third place he contends that carbon does not depend upon vegetable matter for its existence. For instance, carbon constitutes a portion of primitive lime-stone which is admitted by all to have been formed before the existence of vegetable matter. Graphite, composed of 94 per cent. of carbon and 6 of iron, is found in primitive rocks.

In the fourth place he contends that carbon does not necessarily depend upon vegetable matter for any of its modifications. He said that charcoal was found in an aneurismal sack of the bend of a man's leg, and all the specimens of mineral charcoal found in coal beds resembled each other, which proved that they owed their origin to the same chymical cause.

Anthracite and bituminous coal, he says, are crystallized substances—they possess

properties in common with all crystallized substances—they are bounded by regular angles, lines, surfaces, and possessing an incapacity to absorb water. Hence he concludes that they are crystallized besides. And lastly, he says that coal is a mineral deposit—that it was deposited in a summer season, when the smallest quantity of water existed, that the shale above the coal containing vegetable impressions, was deposited in the fall and beginning of winter—that the sandstone above the shale was deposited in the spring by the spring washes, and that the slate under the coal was deposited in the beginning of summer.

Hence he concludes that each bed of coal with the attending rocks, was formed in one year, and that it was a mineral deposit, he supports by the following facts:—

1st. The beds of coal are thicker at the margin of the coal lake or basin than at or near the centre, which accords with the laws of crystalography.

2d. The beds of shale above the coal, are thicker in the centre or bottom of the lake than at the sides, which fact is in accordance with the laws of gravitation.

3d. The quantity of coal is always in the inverse ratio with the quantity of shale, which is explicable by the laws of fluidity.

4th. Some of the coal beds in the same basin are covered in one place with shale, and in another with sandstone, which is explicable upon the principle of local currents.

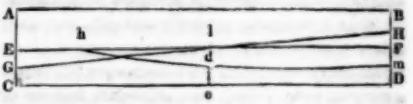
5th. The shale covering the same bed of coal will at one point furnish vegetable impressions, and at another nothing of the kind is to be found, which is explicable upon the principle of local winds.

We shall take occasion to advert to the subject hereafter, and in the mean time would be pleased to receive any geological information, whether in support or refutation of the foregoing theory.

COMMUNICATION.] [FOR THE MAGAZINE.

A Hint to the Proprietors of Bridges.

Mr. Editor,—Having occasion to cross Charles River Bridge very often, the idea has frequently struck me, that in the present system of sawing the planks, there is a great and useless waste of the material. As the grand desideratum in these times, is "to save where we can," (more especially our toll money, for as you perceive the fewer repairs, the lower the tolls must be,) I present the following for the consideration of the proprietors of the bridges around this metropolis, hoping that the saving will be so obvious, that they will be induced to try the experiment, if nothing more. The plan I propose is as follows:—



Suppose ABDC to represent a timber from which two planks of five inches in thickness each, are to be cut. Instead of sawing on the line EF, as is done at present, I would set AG=7 inches, BH=3 inches, and join the two points G and H by the straight line GH, and saw on this line. The figure EhdmDeC is a section of a worn plank, CD=16 feet, EG=5 inches, Eh*=3½ feet, de, taken in the middle of the plank, =3 inches, Dm=3½ inches. From these measurements, I deduce the area of Fhdm, or the part of the plank which is worn off =3,0975 square feet, area HIF=0,6666 square feet. It will be very clear to any one on the mere inspection of the figure that all of the part HIF is gained. Comparing these two areas together, we have 0,6666 : 3,0975 :: 21 : 100, or which is the same, an increase of wearing section of 21 per cent. And as Charles River Bridge is about 1400 feet in length, and 32 in width, the cost of planking it, (at 60 dollars per thousand square feet,) would amount to 2688 dollars, and by cutting the planks in the manner I propose, a saving of more than 560 dollars would be effected. Another advantage would be to afford an easy and agreeable slope by which the water might be discharged into the river. I trust that others may be discovered on further investigation, and after the pains I have taken, if what I have advanced be not true, I hope some one understanding the subject will be induced to correct me.

* *

* It may be observed, that as the carriages pass only within 3 or 4 feet of the railing, the part from E to h suffers no wear.

CHYMISTRY.—OF THE METALS.

Silver.—Silver was known to the nations of antiquity. Its discovery is of an earlier date than the most ancient records of mankind; and it soon became, by its scarcity, its beauty, and its useful properties, the object of the researches of a great number of artists and men of science. It is not astonishing that men, who had caused the metallick substances to assume so many different forms, and who so frequently imitated by alloys the whiteness and several of

the properties of silver, harbored from a very remote period the idea of creating this precious metal by art. When they compared it with the other white metals, it seemed to them to differ from them only in some qualities, and that it would not be impossible to procure it free from those qualities. Not discouraged by their first unsuccessful attempts, in proportion as this precious metal became amongst mankind the representative of all other objects, of all the productions of industry, and even of those of genius, the alchymists redoubled their efforts; and though their experiments and their laborious researches have not had all the success which they expected from them, they have not been entirely lost. It is from these unfortunate trials, accumulated by the labours of ages, that chymists have derived the facts which they have employed in its history; and they have had, as it were, nothing more to do than to arrange, in a methodical order, and clearly to describe the phenomena which this metal had presented, in the tortures of every kind to which alchymists have subjected it.

Whilst the alchymists, who called silver *Luna* or *Diana*, qualified it, even by the sign which they consecrated to it, as a kind of semi-gold, which they represented by two semi-circular lines put together in the same direction, with the horns turned to the left; so that nothing more was necessary than to turn back the interior curve, and unite it with the exterior, in order to form the circular figure, or characteristick sign of gold, to which they believed it to be in fact very nearly related, since it was only required to develope one of its parts, in order to cause it to pass into the state of gold, the last stage of metallick perfection. The labours of the alchymists have extended its numerous uses, and have been no less useful to the chymists in constructing the system of their science. The pharmaceutical operations themselves, though they have been much less numerous upon silver than upon many other metals, have served to increase the stock of chymical knowledge concerning this metal; and it is from the whole of these labours that the history of this important metal has gradually been formed.

Silver is of a fine white colour, and of an extremely lively brilliancy. Whether burnished or otherwise, this metal is the most beautiful that is known, at least in the opinion of most men. In general, it pleases more than any other metallick substance. There is no metal that approaches it in lustre; it holds only the fifth rank amongst the metals with respect to density and specifick gravity; it follows after platina, gold, tungsten, mercury, and lead. Its specifick gravity is 10·474 when melted, and 10·535 when hammered.

With respect to its hardness, it has been placed between iron and gold; this is, however augmented by the action of the hammer, or by pressure. Its elasticity is pretty considerable; and in this respect it is intermediate between gold and copper. It is one of the most sonorous metals, and when struck, it emits a very acute sound.

The ductility of silver is one of its most marked properties; It follows immediately after gold and platina. It is made into leaves so thin, that they are easily wafted away by the wind, and into wires of extreme tenuity. On this account it is instanced in Natural Philosophy, to prove the divisibility of matter. A grain of silver may be sufficiently extended, and at the same time sufficiently firm, to make an hemispherical vessel to contain an ounce of water, or a wire 400 feet in length. It is upon this amazing malleability that the art of gold and silver-beating is founded. It holds the second rank after gold with respect to tenacity, or resistance against breaking. A wire of this metal, one tenth of an inch in diameter, supports a weight of 270 pounds before it breaks. This wire is considerably lengthened before it breaks. Silver is hardened by all kinds of pressure; but it easily acquires its former ductility again by the action of fire, or by annealing.

Silver is a very good conductor of calorick, and becomes heated very quickly. Its expansion by heat is a little inferior to that of lead and tin, and superior to that of iron. When silver has been expanded by heat, and the fire urged till it is heated to whiteness or incandescence, it softens and runs. Its fusibility has been estimated by Mortimer at 1000 degrees of Fahrenheit. When silver has been fused and suffered to cool slowly, it presents at its surface figures similar to net work and fern-leaves, which announce a very marked crystallizability. On breaking it we find a granulated texture, which possesses the same property. Mongez and Tillet, by suffering a liquid portion to run off from a large mass of fused silver, have obtained it crystallized in quadrangular or octahedral prisms; and it affects the same form in nature, as will be afterwards noticed.

Silver is a very good conductor of electricity and galvanism. It has no sensible taste nor smell; neither does it produce any effect upon the animal economy; and though it cannot be considered as dangerous to the health, it must, nevertheless, be reckoned amongst the number of perfectly inert substances, destitute of any medicinal property.

Nature presents silver neither in such abundance, nor in so many places, nor in such large masses, as most of the other metallick substances. Even the number of species that can be distinguished amongst the ores of this metal is infinitely more limited than those which are admitted in most of the other metals. The mineralogists, who have hitherto considered its varieties as species, have moreover committed another error; namely, that of having too closely followed the errors and prejudices of the miners. These, considering as ores of silver all those ores that are capable of affording this precious metal, of whatever nature they may be, which have very much obscured the natural history of this metal.

Pure silver, when exposed to the air, remains in it without alteration, except with respect to its polish and brilliancy; it becomes less shining and a little tarnished at its surface, but without being oxidized. We ought not, however, to confound the kind of covering or stratum of a deep blue colour, which is formed upon old silver plate exposed for a long time to the contact of several gases mixed with the air, with a stratum which, according to the examination of it instituted by Mr. Proust, as merely a sulphuret of this metal. Silver has long been believed to be perfectly indistructible by the contact of the air, even when aided by a very intense heat; and on this account it was ranked amongst the perfect metals. Several chymists, and especially Junker, had advanced, that by treating silver by a long reverberation, and in a furnace where the flame circulated above the metal, the silver was at last converted into a vitriform oxide. It has even been added, that when united with mercury, and divided by this liquid metal, it was oxidized by the processes which are usually employed for converting mercury into red oxide, and which is not improbable.

Many experiments made since the assertion of Junker, and by different processes, have proved that silver is really oxidizable, but only that it is much less so, and with much greater difficulty, than the other metals. Macquer was the first who remarked this oxidation, by exposing silver in a crucible to the intense heat of the furnace of Sevres twenty successive times. At the last time, very sensible traces of oxidation were perceived, and a vitrification of an olive colour. Macquer never failed to observe, when treating silver in the focus of a burning glass, that after a long incandescence, it became covered with a white powder, which formed a stratum upon the support of the silver. Homberg, in the first experiments with the burning glass of Tchirshausen, had made the same observations upon silver and upon gold. It cannot be doubted that these facts indicate a marked oxidation of the silver, and that they become more strong and conclusive when joined with the experiments which we shall mention.

Van Marum made many valuable researches respecting the effects of electricity with the grand machine of Teyler, and found that it took fire and burned. By passing the electrick shock from a battery through a wire of this metal, the wire is suddenly reduced, as it were, into powder, with a greenish white flame, which passes with the rapidity of lightning, and the oxide manifestly formed in this operation is dissipated in smoke. If we perform the same operation by wrapping up the wire, or fixing it upon white paper, it attaches itself to it in a very fine powder of a greenish grey colour, so fine and so adherent, that it resembles smoke, or a light covering which cannot be separated from it again. It is impossible here to doubt either of the state of oxidation of the silver, or of its combustibility; because the phenomenon is constantly accompanied with flame. We may attribute this effect, which is not produced by ordinary fire, however intense it may be, to the extreme division of the metal by the electrick shock, and to the high temperature produced by the electrick composition in the body which is exposed to it. A stroke of lightning upon silver wires and silver furniture, produces exactly the same phenomena, and is followed by the same results.

The oxide of silver formed by these different processes, and which is so difficult to be obtained, is likewise extremely easy of reduction, because the silver adheres to the oxygen very weakly. Though the presence of this body augments its weight, changes its properties, and especially renders it acrid and caustick, nothing more is

required than to expose these greenish or yellowish grey oxides to the contact of the solar rays, in order to make them assume a darker colour, become black, and approach to the metallick state. When we heat them in close vessels, and with the pneumatick apparatus, we obtain from them pure oxygen gas, and easily convert them into the brilliant and ductile metal, by fusing them in a crucible.

Neither carbon nor hydrogen have been combined with silver; but it combines readily with sulphur and phosphorus.

It is well known, that when silver is long exposed to the air, especially in frequented places, as churches, theatres, &c. it acquires a covering of a violet colour, which deprives it of its lustre and malleability. This covering, which forms a thin layer, can only be detached from the silver by bending it, or breaking it in pieces with a hammer. It was examined by Mr. Proust, and found to be *sulphuret of silver*.

Silver does not combine with the simple incombustibles.

Silver combines readily with the greater number of metallick bodies.

When silver and gold are kept melted together, they combine, and form an alloy, composed, as Homberg ascertained, of one part of silver and five of gold. He kept equal parts of gold and silver in gentle fusion for a quarter of an hour, and found, on breaking the crucible, two masses, the uppermost of which was pure silver, the undermost the whole gold combined with 1-6 of silver. Silver, however, may be melted with gold in almost any proportion; and if the proper precautions be employed, the two metals remain combined together.

The alloy of gold and silver is harder and more sonorous than gold. Its hardness is a maximum when the alloy contains two parts of gold and one of silver. The density of these metals is a little diminished, and the colour of the gold is much altered, even when the proportion of the silver is small; one part of silver produces a sensible change in twenty parts of gold. The colour is not only pale, but it has also a very sensible greenish tinge, as if the light reflected by the silver passed through a very thin covering of gold. This alloy, being more fusible than gold, is employed to solder pieces of that metal together.

When silver and platinum are fused together, (for which a very strong heat is necessary,) they form a mixture, not so ductile as silver, but harder and less white. The two metals are separated by keeping them for some time in a state of fusion; the platinum sinking to the bottom from its weight. This circumstance would induce one to suppose, that there is very little affinity between them. Indeed, Dr. Lewis found, that when the two metals were melted together, they sputtered up as if there were a kind of repugnance between them. The difficulty of uniting them was noticed also by Scheffer.

Palladium.—This metal was first found by Dr. Wollaston combined with platina, among the grains of which he supposes its ore to exist, or an alloy of it with iridium and osmium, scarcely distinguishable from the crude platina, though it is harder and heavier.

Palladium is of a greyish white colour, scarcely distinguishable from platina, and takes a good polish. It is ductile and very malleable; and being reduced into thin slips, is flexible, but not very elastick. Its fracture is fibrous, and in diverging strie, showing a kind of crystalline arrangement. In hardness it is superior to wrought iron. Its specifick gravity is from 10·9 to 11·8. It is a less perfect conductor of calorick than most metals, and less expansible, though in this it exceeds platina. On exposure to a strong heat, its surface tarnishes a little, and becomes blue; but an increased heat brightens it again. It is reducible *per se*. Its fusion requires a much higher heat than that of gold; but if touched while hot with a small bit of sulphur, it runs like zinc. The sulphuret is whiter than the metal itself, and extremely brittle.

Nitrick acid soon acquires a fine red colour from palladium, but the quantity it dissolves is small. Nitrous acid acts on it more quickly and powerfully. Sulphurick acid, by boiling, acquires a similar colour dissolving a small portion. Muriatick acid acts much in the same manner. Nitromuriatick acid dissolves it rapidly, and assumes a deep red.

Alkalis and earths throw down a precipitate from its solutions, generally of a fine orange colour; but it is partly re-dissolved in an excess of alkali. Some of the neutral salts, particularly those of potash, form with it triple compounds, much more soluble in water than those of platina, but insoluble in alcohol.

Alkalis acts on palladium even in the metallick state; the contact of air, however, promotes their action.

A neutralized solution of palladium is precipitated of a dark orange or brown colour by recent muriate of tin; but if it be in such proportions as to remain transparent, it is changed to a beautiful emerald green. Green sulphate of iron precipitates the palladium in a metallick state. Sulphuretted hydrogen produces a dark brown precipitate; prussiate of potash an olive coloured; and prussiate of mercury a yellowish white. As the last does not precipitate platina, it is an excellent test of palladium. This precipitate is from a neutral solution in nitrick acid, and detonates at about 500° of Fahr., in a manner similar to gunpowder. Fluorick, arsenick, phosphorick, oxalick, tartarick, citrick, and some other acids, with their salts, precipitate some of the solutions of palladium.

When strongly heated, its surface assumes a blue colour; but by increasing the temperature, the original lustre is again restored. This blue colour is doubtless a commencement of oxidizement; but neither the properties of the oxides of this metal, nor the proportion of oxygen with which it combines, have been ascertained.

The effect of hydrogen upon palladium has scarcely been tried. Chenevix melted the metal in a charcoal crucible, but it was not in the least altered.

Palladium unites very readily to sulphur. When it is strongly heated, the addition of a little sulphur causes it to run into fusion immediately, and the sulphuret continues in a liquid state till it be only obscurely red hot. Sulphuret of palladium is rather paler than the pure metal, and is extremely brittle. By means of heat and air, the sulphur may be gradually dissipated, and the metal obtained in a state of purity.

Azote has probably no effect upon it; but muriatick acid promotes its oxidizement, and forms a red solution with the oxide.

Mercury.—Mercury, like some other metals, appears to have received its name from the planet, with which it was compared by the Persians, on account of its nature, which was supposed to approach to that of gold, as this planet is nearest to the sun, and has been known since the most remote ages of antiquity. From a comparison of its properties with those of silver, it was long ago termed *quicksilver*, *hydrargyrum*. In the species of hieroglyphicks that were formerly employed for representing bodies, mercury was represented by the combined signs of the sun and moon, or of gold and silver linked together, and supported upon a cross.

The alchymists have laboured much upon this metal. They considered it as very much resembling gold and silver, and differing but very little from them; they imagined that it wanted but very little to become either the one or the other, and they always hoped to discover the means of transmuting it into these metals. Some of them have even affirmed, that they had succeeded in effecting this transmutation. These adepts agree with each other, that it is much more easy to convert it into silver than into gold. According to them, in order to convert it into silver, nothing more is required than to fix it. It was, therefore, in this fixation of mercury that they made all the art of their opus magnum, all the marvellous part of their science to consist; this was the grand object of their attention, and the scope of all their wishes. All these pretensions, however, are not supported by a single well-attested fact: and the more we advance in the study of the properties of mercury, the more differences we find between it and the metals to which it has been supposed to approach the nearest.

The most celebrated philosophers, and the most able chymists, have all successively occupied themselves with this metal: they have endeavoured to ascertain all its properties with more or less precision; and the use which has been made of it since the end of the last century, or since the time of Boyle, in the construction of a great number of philosophical instruments, has afforded frequent occasion for investigating and examining its different characters. It is in this manner that its weight, its phosphorescence, its dilatibility, its volatility, its alterability, its mobility, &c. have been successively ascertained.

The application of the pneumatick chymistry has connected together all the known facts relative to the chymical properties of mercury; it has given rise to the discovery of a considerable number of new ones; it has elucidated a great number of facts which before could not be explained; it has drawn from oblivion several which were neglected, or in a manner abandoned; it has dissipated all the obscurity, ambiguity, or uncertainty that remained in the enunciation of its properties; it has conducted Chymists to several important discoveries: such as the mutual differences between the greater part of the metallick or mercurial salts; the comparative state of the different oxides of mercury; the action of each oxide upon this metal or its oxides; the for-

mation of several triple salts; the cause of the energy and causticity of the mercurial salts or oxides; the spontaneous reduction of these oxides; their decompositions by some of the metals; the nature and characters of several precipitates; the different states of some of its solutions; the extinction of mercury in a number of substances, which had always been considered as a simple division, but which, in reality, is a true oxidation. Mercury being one of the most useful of metallick substances for medical purposes, for the arts, and for all those branches of knowledge which extend our views of nature, we shall [in our next] give a full detail of its properties.

THE AMERICAN ALMANAC

And Repository of Useful Knowledge.—Gray & Bowen, of Boston, have published the second volume (for 1831) of the above work; and, like its predecessor, it is replete with useful information. The conductors say, in their preface to the work, "It is intended to form a series of volumes, so diversified in their contents, as to form a library of Useful Knowledge, exhibiting the most important facts of contemporary history, the statisticks of the globe, views of the state and progress of society, and miscellaneous information on the different departments of human knowledge and active life," and from a hasty glance at the work, we think it fully corroborates the assertion.

The astronomical department is by R. T. Paine. Esq. In his Preliminary Observations, he says:—

"The year 1831 is peculiarly distinguished for phenomena worthy of the attention of the astronomers of the United States.

The eclipse on the twelfth of February is the first of a very remarkable series of five large eclipses of the sun, visible to us in the short term of seven years. The others happen as follows; the first on the 27th of July, 1832, total in Cuba; the second on the 30th of November, 1834, total in Charleston, Beaufort, &c. in South Carolina; the third on the 15th of May, 1836, annular near Cuba; and the fourth on the 18th of September, 1838, annular in three-fifths of the States of the Union.

The eclipse of the present year, taking place near noon, will of course attract great attention. Should the sky be clear, at the time of the nearest approach of the centres of the Sun and Moon, much diminution of the light is not to be expected, probably not enough to render visible the planet Venus, then about 13 degrees *east* of the Sun; but a very considerable effect on the thermometer will doubtless be noticed; and, for half an hour, the power of a lens to produce combustion, by refracting the solar rays, will be entirely destroyed. If the day should be cloudy, the darkness will probably be complete.

The occultations this year are uncommonly numerous; and several years must elapse before as many eclipses of stars of the first magnitude, and of the principal planets, can again be expected."

There are many valuable statisticks in the present number, which, only deep research, and great labor, could have produced. It also contains some scientifick articles, two of which we subjoin below.

It is a work we would recommend to the publick, and, although the price is *One Dollar*, (a great sum for a *mere* almanack,) yet we would remind the reader that in exchange for his dollar, he gets above 300 well-printed duodecimo pages of Useful Information.

DENSITY OF THE EARTH.

Is the earth solid or hollow, and if solid, how dense is it? Would it be equivalent to so much water, or would it exceed it, and how much would it exceed it? It may seem very difficult to answer these questions, and yet they have been answered most satisfactorily. It is now abundantly proved not only that the earth is solid, but that the interior parts are more and more compact the nearer we approach to the centre, as we should naturally suppose. We are able to estimate the influence which a mountain exerts upon a plumb-line by observing how much it is drawn out of the direction of an exact perpendicular; and then, by comparing the size of the mountain with the size of the earth, knowing at the same time of what materials the mountain is composed, we are able to say how much the matter of the whole earth exceeds that of the mountain. It is thus ascertained that the matter composing the earth is about five times as dense as water, or, in other words, would weigh, under the same circumstances, five times as much as the same bulk of water. Now we know that the matter near the surface, is, for the most part, either water or earthy and stony

substances, only two or three times as heavy as water. The density of the interior parts, therefore, must greatly exceed that at the surface, in order that the average may amount to five times the density of water, as is ascertained by actual observation.

It may be thought, that the above method of determining the quantity of matter in a mountain is liable to great uncertainty. It should be known that we do not rely upon a single experiment, or even upon one single method, for so important a result. A balance has been contrived, depending upon the twisting and untwisting of an extremely fine wire, suspended perpendicularly,* by which the mutual tendency (or relative weight) of two balls of lead, has been accurately estimated and compared with the force exerted by the great mass of the earth; and these delicate experiments have afforded a striking confirmation of the result above stated.

TEMPERATURE OF THE INTERIOR OF THE EARTH.

The circumstance of the earth's being flattened at the poles and protuberant at the equator, is the natural and necessary result of its rotation on its axis. But in order that it might yield to the force resulting from such a motion, the matter of which it is composed, must have been soft. Now, although water is capable of being compressed, and so far as we can judge, of taking any degree of density, according to the force exerted upon it, still the shape of the earth is not that which would have resulted from such a mass of water. There may be particular portions of the sea that extend to the depth of several miles, as there are particular points of the solid crust of continents, that rise to this height above the general level. Still we have reason to believe, that the average depth of the ocean does not much exceed three thousand feet. It is thought that heat may have been the original cause of the fluidity of the earth, and that there may still remain enough to keep the interior portions in the same state. The more this subject has been examined, the more the evidence has accumulated in favor of the position that the temperature increases as we descend below the surface. There are numerous instances in which we have been able, by means of natural or artificial excavations, to penetrate to the depth of from 1300 to 1600 feet. The general inference from all the observations made in different parts of the earth is, that there is an increase of heat amounting to about 1° of Fahrenheit for every 46 feet in depth; that at the depth of 10,000 feet the heat would be sufficient to boil water, and that at the depth of about 100 miles, or $\frac{1}{47}$ part of the distance to the centre, the heat would be intense enough to melt most of the earths and stones that are known to enter into the composition of the globe. These facts and inferences have an important bearing upon the phenomena of earthquakes and volcanoes, and open a wide field of speculation to the natural historian and geologist.

* A balance of this construction, applied to electrical forces, has been estimated to weigh to the sixty-thousandth part of a grain.

SINGULAR APPLICATION OF HEAT.

Some years ago it was observed, at the *Conservatoire des Arts et Metiers* at Paris, that the two side-walls of a gallery were receding from each other, being pressed outwards by the weight of the roof and floors. Several holes were made in each of the walls, opposite to one another, and at equal distances, through which strong iron bars were introduced, so as to traverse the chamber. Their ends outside of the wall were furnished with thick iron discs, firmly screwed on. These were sufficient to retain the walls in their actual position. But to bring them nearer together would have surpassed every effort of human strength. All the alternate bars of the series were now heated at once by lamps, in consequence of which they were elongated. The exterior discs being thus freed from contact of the walls, permitted them to be advanced farther, on the screwed ends of the bars. On removing the lamps, the bars cooled, contracted, and drew in the opposite walls. The other bars became in consequence loose at their extremities, and permitted their end plates to be further screwed on. The first series of bars being again heated, the above process was repeated in each of its steps. By a succession of these experiments they restored the walls to the perpendicular position; and could easily have reversed their curvature inwards, if they had chosen. The gallery still exists, with its bars, to attest the ingenuity of its preserver, M. Molard.

FORMATION OF WAVES.

When the surface of water is unequally pressed on, in parts contiguous to one another, the columns most pressed on are

shortened, and sink beneath the natural level of the surface, while those that are least pressed on are lengthened, and rise above that level.

As soon as the former columns have sunk to a certain depth, and the latter have risen to a certain height, their motions are reversed, and continue so till the columns that were at first most depressed have become most elevated, and those that were most elevated, have become most depressed.

The alternate elevations and depressions thus produced, are called *waves*.

The water in the formation of waves has a vibratory or reciprocating motion, both in a horizontal and a vertical direction, by which it passes from the columns that are shortened to those that are lengthened, and returns again in the opposite direction, progressive motion not being necessary to undulation.

The vibrations of water in the form of waves, may be compared to the reciprocations of the same fluid in a syphon or bent tube; and it was from this that Newton deduced the velocity of waves, and the time required for an undulation.

The *time* of an undulation, is the time from the wave being highest, at any point, to its being highest at that point again. The *velocity* of the wave is the rate at which the points of greatest elevation or depression seem to change their places.

If the altitude and breadth of a wave be known, the time of an undulation and the space which the wave appears to pass over may be determined as follows. To find the *time* of an undulation, add half the breadth of the wave to its altitude, multiply the sum by ·3927, and the square root of the product will be the time in seconds.* Thus, suppose the breadth of a wave to be 14 feet, and its height 3 feet, required the time of an undulation. Here the sum of the height and half the breadth is 10, which multiplied by ·3927, becomes 3·927, the square root of which is 2, nearly, the number of seconds in which an undulation is performed.

To find the *space* which the wave passes over in one second:—Divide half the breadth of the wave by the square root of the sum of the altitude, and half the breadth, multiplied by 3·927, and the result will be the space passed over by the wave in one second.

* This number is one-eighth of the circumference of a circle whose diameter is 1.

Thus, suppose the breadth and height of a wave to be as stated in the preceding example, and it is required to find the space it will pass over in a second of time. Here the square root of 10 is 3·1, nearly, which multiplied by ·3927 is 1·22, nearly; and 7 divided by this number quotes 5⅔, nearly, which is the space passed over in one second.

While the depth of the water is sufficient to allow the oscillation to proceed undisturbed, the waves have no progressive motion, and are kept, each in its place, by the action of the waves that surround it. But if by a rock rising near the surface, or by the shelving of the shore, the oscillation is prevented, or much retarded, the waves in the deep water are not balanced by those in the shallower, and therefore acquire a progressive motion in this last direction, and form *breakers*. Hence it is, that waves always break against the shore, whatever be the direction of the wind.

Breakers formed over a great extent of shore, are distinguished by the name of *surf*. The surf is greatest in those parts of the earth where the wind blows always nearly in the same direction: but in the foregoing observations, no allowance is made for winds.—(Artisan.)

RAIL ROADS IN SCHUYLKILL CO.

The following rail roads will be ready for the transportation of coal, on the opening of the navigation in the spring:

The Schuylkill Valley Rail Road, (which has been in full operation the greater part of the present season,) commences at Port Carbon and terminates at Tuscarora, a distance of 10 miles. There are also 15 lateral rail roads intersecting it, the distances of which combined will amount to about 10 miles. The main-branch cost $55,000, and the laterals, we presume, about $20,000.

The Mill Creek Rail Road, (which has also been in operation the present season,) commences at Port Carbon, and extends up Mill Creek four miles. This road cost about $14,000. There are about three miles of lateral roads intersecting the main branch, which cost about $2000 per mile.

The West Branch Rail Road, (one track of which is now in operation,) commences at Schuylkill Haven and terminates at the foot of the Broad Mountain. The length of said road, including the West Branch, will be 15 miles, and will cost upwards of $150,000. There are also about five miles

of lateral roads intersecting it, the average cost of which will be about 2000 per mile.

The Mount Carbon Rail Road, commences at Mount Carbon, and extends up the two branches of the Norwegian, a distance of 9 miles, which will cost about $100,000. A number of lateral roads on this have also been commenced.

RECAPITULATION.

	Miles.	*Cost.*
Schuylkill Valley Road	10	$55,000
Laterals intersecting do.	10	20,000
Mill Creek Road	4	14,000
Laterals intersecting do.	3	6,000
West Branch Road	15	150,000
Laterals intersecting do.	5	10,000
Mount Carbon Road	9	100,000
Total	56	$355,000

The following Rail Roads have been commenced in this county:

The Pinegrove Rail Road, which extends from the Mines to the Swatara feeder, a distance of five miles. This road will cost about $30,000, and be completed early next season.

The Little Schuylkill Rail Road, commences at Port Clinton, and extends up said stream to the mines, a distance of about 23 miles. This road, it is expected, will be completed next season, if laid with wooden rails. If iron rails should be concluded on, the time for completion, of course, must be extended. This road, if constructed with wooden rails, will probably cost $250,000—if constructed with iron rails, about $400,000. Making 84 miles of Rail Road, at an expense of $635,000.

All the above Rail Roads have been commenced within the last two years, and when completed will yield a fair per centage on the capital invested.

Thus after raising so noble a monument to our industry and fame, some do not hesitate to say that we are all *mad*. "We are not *mad* most noble" revilers. If so, such was the *madness* of those who projected the Schuylkill Navigation.—*Miners' Jour.*

ENGRAVING.

The art of engraving on copper was invented in Europe in the first half of the fifteenth century. The Chinese seem to have been acquainted with it long before. The Dutch, the Italians, and the Germans compete for the honor of its invention in Europe. It is known that the art was exercised by the Italian Finiguerra as early as 1460. The inventors of it were the gold smiths, who were in the habit of making devices on their wares; and these being often executed with much elegance, excited the desire to multiply copies by transferring them to paper. Engraving differs from printing in having its subjects cut into a hard surface, instead of being raised above it, as is the case with types and wood cuts. Many metals and alloys have been employed for the purpose of engraving. The most common is copper, which is soft enough to be cut when cold, and hard enough to resist the action of the press.

Engraving of Mezzotintos.—This method of producing prints which resemble drawings in India ink, is said by Evelyn, in his history of chalcography, to have been discovered by prince Rupert. Some accounts say that he learned the art from an officer named Siegen or Sichem, in the service of Hesse-Cassel. It was some years past, a very favorite way of engraving portraits and historical subjects: of the former, the large heads of Fry are of superior excellence. The tools required for this easy and rapid mode of proceeding are, the grounding tool, the scraper and the burnisher. The copper-plate should be prepared as if intended for the graver, and laid flat upon a table, with a piece of flannel spread under it, to prevent the plate from slipping; the grounding-tool is then held perpendicularly on it, and rocked with moderate pressure backwards and forwards, till the teeth of the tool have equally and regularly marked the copper from side to side; the operation is afterwards repeated from end to end, and from each corner to the opposite; but it is necessary to observe that the tool must never be permitted to cut twice in the same place; by this means the surface is converted into a rough chaos of intersections, which, if covered with ink and printed, would present a perfectly black impression upon the paper. This is the most tedious part of the process. The rest, to a skilful artist, is much easier than line engraving or stippling. It consists in pressing down or rubbing out the roughness of the plate, by means of the burnisher and scraper, to the extent of the intended figure, obliterating the ground for lights, and leaving it for shades. Where a strong light is required, the whole ground is erased. For a medium light it is moderately burnished, or partially erased. For the deepest shades, the ground is left entire. Care is taken to preserve the insensible gradations of light and

shade, upon which the effect and harmony of the piece essentially depend. Engraving in mezzotinto approaches more nearly to the effect of oil-paintings than any other species. It is well calculated for the representation of obscure pieces, such as night scenes, &c. The principal objection to the method is, that the plates wear out speedily under the press, and, of course, yield a comparatively small number of impressions.

Etching.—Of engravings which require the aid of aquafortis, the principal is etching. He that would excel in this branch of the arts must be thoroughly acquainted with drawing. The ground used in etching is a combination of asphaltum, gum mastick and virgin wax. The proportions of the ingredients should be obtained by experiment. The copper-plate is hammered to a considerable degree of hardness, polished as if intended for the graver, and heated over a charcoal fire; the ground is then rubbed over it, till every part is thinly and equally varnished. The varnish is then blackened by the smoke of a lamp, that the operator may see the progress and state of his work. The next object is to transfer the design to the ground, which may be done by drawing it on thin white paper with a black-lead pencil, and having it passed through the copper-plate printer's rolling press; the lead will be conveyed firmly to the ground, which will appear in perfect outlines on removing the paper. Another method is, to draw the design reversed from the original; rub the back with powdered white chalk, and, laying it on the ground, trace the lines through with a blunt point: this operation requires much precaution, or the point will cut the ground. After the plate is prepared, the operator, supporting his hand on a ruler, begins his drawing, taking care always to reach the copper. Every line must be kept distinct, throughout the plate, and the most distant should be closer and more regular than those in the fore ground, and the greater the depth of shade, the broader and deeper must the lines be made. When the etching of the plate is completely finished, the edges of it must be surrounded by a high border of wax, so well secured that water will not penetrate between the plate and it. The best spirits of aquafortis must then be diluted with water, and poured upon the plate, which undergoes a chymical action wherever it has been laid bare by the needle, while the remainder of the surface is defended by the varnish. The bubbles of fixed air, and the saturated portions of metal are carefully brushed away with a feather. After the operator thinks the acid has acted long enough, he pours it off, and examines the plate. If the light shades are found to be sufficiently bit in, they are covered with varnish, or *stopped out.* The biting is then continued for the second shades, which are next stopped out: and so on. After the process is completed, the varnish is melted and wiped off, the plate cleaned with oil of turpentine, and any deficiencies in the lines remedied with the graver. As the acid cannot be made to act with perfect regularity, etchings will always be rough in comparison with line engravings. This very circumstance, however, fits etching for the representation of coarse objects in nature, such as trunks of trees, broken ground, &c. especially on a large scale. In landscape engraving we generally find a mixture of methods, the coarser parts being etched, the more delicate cut with the graver. Letters and written characters are mostly cut, and seldom etched.

Steel Engraving was introduced by our celebrated countryman, Mr. Perkins. The steel plate is softened by being deprived of a part of its carbon; the engraving is then made, and the plate hardened again by the restoration of the carbon. The great advantage of steel plates consists in their hardness, by which they are made to yield an indefinite number of impressions; whereas a copper plate wears out after 2 or 3000 impressions, and even much sooner if the engraving be fine. An engraving on a steel plate may be transferred, in relief, to a softened steel cylinder by pressure; this cylinder, after being hardened, may again transfer the design, by being rolled upon a fresh steel plate, thus the design may be multiplied at pleasure. Steel plates may also be etched.

Engraving on Precious Stones is accomplished with the diamond or emery. The diamond possesses the peculiar property of resisting every body in nature, and, though the hardest of all stones, it may be cut by a part of itself, and polished by its own particles. In order to render this splendid substance fit to perform the operations of the tool, two rough diamonds are cemented fast to the ends of the same number of sticks, and rubbed together till the form is obtained for which they are intended; the powder thus produced is preserved, and used for polishing them in a kind of mill furnished with a wheel of iron; the diamond is then secured in a brazen dish, and the dust, mix-

ed with olive oil, applied; the wheel is set in motion, and the friction occasions the polished surface so necessary to give their lustre due effect. Other stones, as rubies, topazes and sapphires, are cut into various angles on a wheel of copper; and the material for polishing those is tripoli diluted with water. A leaden wheel, covered with emery mixed with water, is preferred for the cutting of emeralds, amethysts, hyacinths, agates, granites, &c. &c.; and they are polished on a pewter wheel with tripoli: opal, lapis lazuli, &c. are polished on a wheel made of wood. Contrary to the method used by persons who turn metals, in which the substance to be wrought is fixed in the lathe, turned by it, and the tool held to the substance, the engraver of the crystal, lapis lazuli, &c. fixes his tools in the lathe, and holds the precious stone to them, thus forming vases, or any other shape, by interposing diamond dust mixed with oil, or emery and water, between the tool and the substance, as often as it is dispersed by the rotary motion of the former. The engraving of armorial bearings, single figures, devices, &c. on any of the above stones, after they are polished, is performed through the means of a small iron wheel, the ends of the axis of which are received within two pieces of iron, in a perpendicular position, that may be closed, or otherwise, as the operation requires; the tools are fixed to one end of the axis, and screwed firm; the stone to be engraved is then held to the tool, the wheel set in motion by the foot, and the figure gradually formed. The material of which the tools are made is generally iron, and sometimes brass; some are flat, like chisels, gouges, ferules, and others have circular heads. After the work is finished, the polishing is done with hair brushes fixed on wheels, and tripoli.

Engraving in Wood has been practised for several centuries, and originally with tolerable success; it languished for a great part of the 18th century, but revived towards the close, and is still practised in a manner which reflects credit on the ingenuity of the age. The lines, instead of being cut into the substance, are raised like the letters of printing types, and printed in the same manner. The wood used for this purpose is box, which is preferred for the hardness and closeness of its texture. It is cut across the grain, into pieces of the height of common types, that the engraving may be made upon the end of the grain, for the sake of strength and durability. The surface must be planed smooth, and the design drawn on it with a black-lead pencil; the graver is then used, the finer excavations from which are intended for white interstices between the black lines produced by leaving the box untouched, and the greatest lights are made by cutting away the wood entirely, of the intended form, length and breadth; but the deepest shades require no engraving. Much of the beauty of this kind of engraving depends upon the printing. A recent improvement has been made in wood engraving, which is this: The blocks are prepared as before, and then covered with flake white. The drawing is then made on this, and the wood engraver has only to cut out the lights. The beautiful wood cuts, executed by Branston & Wright, for the Tower menagerie and zoological gardens, (after designs by Harvey,) recently published in London, are executed in this manner. Wood engravings have this advantage, that they may be inserted in a page of common types, and printed without separate expense. They are very durable, and may be multiplied by the process of stereotyping.—(Encyclopædia Americana.)

HYDROGEN GAS.

Chymists have never been able to procure it in a pure and separate state, and they have yet no proof that it exists in that state in nature. In order to discover its properties, they are obliged to examine the bodies which contain it, and by this means they are, in some measure, enabled to discover the properties it communicates to those bodies.

Though we have long possessed some knowledge of the natural inflammable vapours of the mines, and coal pits, as well as of those which are disengaged in many operations of chymistry, such as the metallick solutions in the acids, &c.; it was not till 1766 that M. Cavendish ascertained the existence of this elastick fluid, and properly distinguished it from all others, by collecting it separately, and distinguishing its properties.

Hydrogen gas is not to be collected from natural bodies. That which is abundantly disengaged from fossil coal, moistened or exposed to the air, of putrid vegetables at the bottom of stagnant waters, of ponds, of marshes, of peat soil, contains but a small quantity of pure hydrogen gas. It contains many different substances in solution, and its properties vary singularly according to the number and the proportion of these

substances. It is the same with what exhales from flaming volcanos, red lava flowing into water, and from sulphureous mineral waters. It will be shown hereafter, that these gases are rather different species of inflammable gases, of which hydrogen gas indeed constitutes the base, but in which this gas is the solvent of many different matters, and in various proportions.

Hydrogen gas is the lightest species of ponderable matter yet known. It can be procured only from water, of which it forms an essential constituent. The method of procuring it is as follows. Into a phial or gas bottle, furnished with a bent tube, which is ground to fit the mouth of the phial; put some pieces of pure re-distilled zinc, or harpsichord iron wire, and pour on them sulphurick acid, diluted with five times its bulk of water. An effervescence will ensue, occasioned by the decomposition of the water, and disengagement of hydrogen, which may be collected in the pneumatick apparatus. For very accurate researches, it must be received in jars over mercury, and exposed to the joint action of dry muriate of lime, and a low temperature. It is thus freed from hygrometrick water. In this state its specifick gravity is 0·0694, at 60° F. and 30 inches of barom. pressure. 100 cubick inches weigh 2,118 grains. It is therefore about 14·4 times less dense than common air; 16 times less dense than oxygen: and 14 times less dense than azote. When it stands over water at 60°, its sp. gr. acquires an increase of nearly one-seventh; and it becomes about 0·0790. From the great rarity of hydrogen gas, it is employed for the purpose of inflating varnished silk bags, which are raised in the air, under the name of balloons.

This gas is colourless, and possessed of all the physical properties of air. It has usually a slight garlick odour, arising probably from arsenical particles derived from the zinc. When water is transmitted over pure iron in a state of ignition, it yields hydrogen gas free from smell. It is eminently combustible, and, if pure, burns with a yellowish-white flame; but from accidental contamination, its flame has frequently a reddish tinge. If a narrow jar, filled with hydrogen, be lifted perpendicularly, with the bottom upwards, and a lighted taper be suddenly introduced, the taper will be extinguished, but the gas will burn at the surface, in contact with the air. Animal life is likewise speedily extinguished by the respiration of this gas, though Sir H. Davy has shewn, that if the lungs be not previously exhausted by a forced respiration, it may be breathed for a few seconds without much seeming inconvenience.

When five measures of atmospherick air are mixed with two of hydrogen, and a lighted taper, or an electrick spark, applied to the mixture, explosion takes place, three measures of gas disappear, and moisture is deposited on the inside of the glass. When two measures of hydrogen, mixed with one of oxygen, are detonated, the whole is condensed into water. Thus, therefore, we see the origin of the name *hydrogen*, a term derived from the Greek, to denote the *water-former*. If a bottle, containing the effervescing mixture of iron and dilute sulphurick acid, be shut with a cork, having a straight tube of narrow bore fixed upright in it, then the hydrogen will issue in a jet, which, being kindled, forms the philosophical candle of Dr. Priestley. If a long glass tube be held over the flame, moisture will speedily bedew its sides, and harmonick tones will then begin to be heard. Mr. Faraday, in an ingenious paper inserted in the 10th Number of the Journal of Science, states, that carbonick oxide produces, by the action of its flame, similar sounds, and that therefore the effect is not due to the affections of aqueous vapour, as had formerly been supposed. He shews, that the sound is nothing more than the report of a continued explosion, agreeably to Sir H. Davy's just theory of the constitution of flame. Vapour of ether, made to burn from a small aperture, produces the same sonorous effect as the jet of hydrogen, of coal gas, or olefiant gas, on glass and other tubes. Globes from seven to two inches in diameter, with short necks, give very low tones; bottles, Florence flasks, and phials, always succeeded; air jars, from four inches diameter to a very small size, may be used. Some irregular tubes were constructed of long narrow slips of glass and wood, placing three or four together, so as to form a triangular or square tube, tying them round with pack-thread. These held over the hydrogen jet, gave distinct tones.

In the Philosophical Magazine, we have the following notice of the effect of hydrogen gas on the voice: "The *Journal Britannique*, published at Geneva by Prevost, contains the following article: 'Maunoir was one day amusing himself with Paul at Geneva, in breathing pure hydrogen gas. He inspired it with ease, and did not per-

ceive that it had any sensible effect on him, either in entering or passing out of his lungs. But after he had taken in a very large dose, he was desirous of speaking, and was astonishingly surprised at the sound of his voice, which was become soft, shrill, and even squeaking, so as to alarm him. Paul made the same experiment on himself, and the same effect was produced. I do not know whether any thing similar has occurred in breathing any of the other gases.'"

VITALITY OF MATTER.

The mystery of life, or the cause of sensation and voluntary motion, has been a subject of the deepest interest in all ages of the world. The curious and the learned have instituted the most diligent inquiries to discover whether the hidden principle is an emanation from the divinity or a supernatural gift, or whether it resides in the organized structure, by some particular disposition and consent of parts; or whether each particle possesses inherent powers of life in its separate state, and thus spontaneously arises from decaying forms to engage in new scenes of activity.

Within a few years, from some investigations with the microscope, a theory has arisen, which maintains that this mysterious principle is inherent in the elementary forms of matter, and that they assume new shapes, and revive in their primitive activity, whenever death changes their aspects.

These doctrines, adopted in their full extent, restore the dogmas of the metempsychosis, and the chances of Democritus, and, by vulgar induction, end in atheism. Without the dignity of that system of which Epicurus, Lucretius, Pliny, and Lucian were disciples, they fall into the materialism of Leibnitz, who considers "each monad or atom possessed of perception and appetite. This appetency produces an internal principle of alteration—hence the sympathies and affinities, the combinations and forms of bodies."

The Epicurean theory, although it deemed matter eternal and insensate, and that its particles, by jostling forever, had at length adhered in masses, ultimately forming the world itself, inhabited by animals, and clothed with vegetation; yet it taught that it was operated upon by an immaterial divinity, and that life was imparted by a divine invisible power, who ruled over all.

In later times, Sir Isaac Newton built a noble superstructure upon the principle asserted in the Mosaick account of the creation—that all things were made by an omnipotent, immaterial, intelligent being; that he established those immutable laws by which the universe is regulated and governed; and that he imparted animation to creatures by bestowing upon them the breath of life.

But Dr. H. M. Edwards, an English physician in Paris, and Dumas, Detrochet, Prevost, and others, have ascertained to their own satisfaction, by some elaborate discoveries by the microscope, that the elementary, organick, constituent parts of animal and vegetable bodies, inherently and independently possess the vital principle—that spirit of life which has hitherto been veiled in mystery. Edwards describes the animal body as "built of animalcules, as a pyramid is built of bricks," being a congeries of countless millions of organized units, "each capable of living in a separate state," and perhaps exercising the functions of individual life, while incorporated in one being. He teaches that these monads or globules, being of the 1-8000 part of an inch in diameter, by one arrangement form the various tissues and fibres of the animal structure, and by another arrangement spring up in the glowing colours and varieties of vegetable life; and that when death passes upon them, and decomposition separates the parts, elements which were before parts of some animal, become vegetables, or it so may chance, vegetable atoms awake to life as animals.

These inferences rest on the following experiments:—

Dr. Edwards examined a piece of animal substance macerated in water, and immediately perceived a number of white vesicles moving about with great rapidity. These he considered to be animalcules of the tribe monads. He observed that these monads lost all power of motion when the water evaporated. "If water were added *immediately* after the cessation of motion, they again began to move, but if allowed to remain dry for a short time, they never recover the faculty of locomotion." He also observed, that "whenever they adhered to the sides of the glass, they exhibited every appearance of vegetable life."

The same experimenter macerated a leaf of the horse-chesnut, and "as soon as the particles became detached from the margin of the leaf, they were seen to put themselves in motion;" thus showing that

when the tissue of plants is decomposed in water, its component organick parts possess independent life, and spontaneous motion.

Another example, though not included in those mentioned by Dr. Edwards, is still more surprising, as it would suggest that the degree of heat which destroys life in visible objects, had the effect, while life was in its invisible state, to aid in its developement. "A potatoe was boiled in water until it became of a mealy consistence. It was closely covered in a glass vessel, and a drop of the water was examined twenty-four hours after, when it exhibited innumerable animalcules in great activity."

From these examples, they conclude that sensation and voluntary motion reside in matter: that, however minutely the parts are dissociated, they still possess a principle of vitality; "that death does not destroy their susceptibility; and that life and matter are co-existent, and from everlasting to everlasting."

These data and the inferences deduced from them, being at variance with those visible facts, and those unerring, invariably recurring rules called the laws of nature, an inquiry respecting them is justified.

Microscopick discoveries are peculiarly liable to error. They require great acuteness and accuracy of sight; and the contradictory conclusions made by the most exact observers with the microscope, render it of doubtful validity. As it would be unfortunate to build a principle in physiology upon an optical illusion, those appearances which have been adduced should be received with great caution, because, if the first point is wrong, every succeeding step must be erroneous, and all further reasoning upon it would be confirming the deception.

A fallacy may therefore be suspected in those appearances which were considered as voluntary motions. It is worthy of remark, that the monads were viewed through the refracting medium of water, and that many of the fibres retained their thread shaped forms, while others, still farther divided, were reduced to points or globules. Being so attenuated as to be scarcely visible, the progress of decomposition, producing a further separation of parts, and moving them by chymical action, might easily cheat the senses with the appearance of animation. While the motions accompanying a chymical process are visible to our unassisted sight, they excite no surprise. A piece of sugar rises and falls in a glass of water, bubbles agitate the mass with motions which appear to be inherent, but these phenomena are not suspected of bearing any relation to life. The motions of the eye stone in a plate of vinegar have been attributed to animal life; but as it is a calcareous stone, the motions are obviously referrible to the action of the acid upon it, which, disengaging a gas, impels it mechanically from side to side. Gaseous particles, disengaged or acquired at the precise point of time when those macerated materials were under examination, by effecting a moving impulse upon them, aided by the refraction of the water and minuteness of the particles, might produce a resemblance to life, although by no means a demonstration that they possess vitality. Further proof is unattainable, as the subject eludes further inspection.—(Silliman's Journal.)

TRANSFERRING PRINTS

To the surface of wood, and either reversing them or not. And on making and applying hard white spirit varnish.

This process is very analogous to that formerly employed in transferring prints to the surface of glass, and to the back of which prints, colours were afterwards applied so as in some degree to imitate oil pictures. Here, however, they are applied upon the surface of wood, such as cornel, sycamore, horse-chesnut, satin wood, *aer wood*, or the curly veined maple, &c., which is afterwards to be varnished.

The wood having been planed smooth and even, is to have a slight coat of the best glue applied upon it; when this has become dry, it must be rubbed with Dutch rushes, or glass paper, to remove the small filaments which the glue has raised, and render the surface uniform. We then apply a layer of white alcoholick varnish, taking care not to cross the marks left by the brush, and pass as few times as possible over the same place; it is then left to dry. We afterwards apply in succession, three, four, five or six other coats of varnish upon it according as the varnish may be thinner or thicker. The edges of the print are then to be cut close to the engraving, and it must be laid upon a proper table, with the impression downwards; it must then be uniformly moistened with a wet sponge, or in any other manner. When it has been equally and thoroughly wetted it must be placed between two leaves of blotting paper, in order to remove any drops of water. We then apply another coat of varnish over the surface of the wood, and

before it has become dry, apply the moistened print upon it with the engraving downwards. In order to do this, we lay one edge of the print first upon the surface of the wood, holding it suspended by the other hand, and wipe successively over the back of the print in such a manner as to drive out all the air, and prevent the formation of blisters. We then lay a sheet of dry paper upon it, and pass a linen cloth over every part of the print, in order to fix it securely upon the varnish. We must take great care to place the print steadily upon the varnished wood, lest we may make a false or distorted impression of it. We then leave it to dry. And when it has become thoroughly dry, we moisten the back of the paper with a sponge, and pass or lightly rub the fingers backwards and forwards over it repeatedly, so as to remove the moistened paper in small rolls curled up. When, however, the marks of the picture begin to appear, we must take care lest in rubbing, we should remove any portion of the paper upon which the impression is taken. When we find, therefore, that we can remove no more of the paper, without incurring the risk of injuring the print, we suffer it to dry. In drying, the engraving will entirely disappear at the back of the print, it remaining covered with a slight film of paper. But on again giving one coat of varnish, it will be rendered entirely transparent. It must then be again suffered to become quite dry. If by chance we have raised any small parts of the engraving, we must retouch those defects with fine lamp black and gum water, before we proceed to varnish, as we before mentioned; great care must be used in laying on a second coat of varnish, passing rapidly over the retouched parts. When this last coat of varnish is perfectly dry we may remove any projecting part of the paper, and polish it with Dutch rushes steeped for three or four days in olive oil; we then remove the oil by rubbing with a fine linen cloth and sprinkle it all over with starch or hair powder, this will absorb the least remains of the oil, and we remove it by first passing the palm of the hand over it, and then by carefully wiping or rubbing it with a fine linen cloth, we next apply three or four more layers of varnish, taking care to let it dry between each coat. When the last coat has become quite dry, (in three or four days time,) we polish the varnish with a piece of fine woollen cloth, and chalk or whiting of the finest kind. In order to prepare this fine chalk, we must grind the ordinary chalk in a mortar with a little water; and when it is well ground we add more water, and pour it into a glass vessel, suffering it to remain at rest for five or six minutes, it will then have deposed its coarser particles. We then decant the liquid which holds in suspension the finer particles of chalk, let it rest, and when the water has become clear we pour it off, and shall find the sediment in the form of a paste, and which we use to polish the varnish with. We must take care to use it in the moist or wet state, as, if it becomes dry, it is impossible to preserve it in the minutely divided state, and we should run the risk of polishing the varnish in streaks. If, however, we would have the varnish still more shining, we must wash off all the remains of this fine chalk with water, and polish it with the palm of the hand only slightly moistened. But to have it still more brilliant, after having washed away all the chalk and suffered it to become quite dry, we must pass all over it a thin coat of varnish, either in the sunshine, or near a warm stove, in order that the varnish may be extended uniformly upon the surface.

White Spirit of Wine Varnish.

Rectified spirit of wine	24 ozs.
Fine Sandarach	4
Fine turpentine	1
Spirit, or oil of turpentine	1
Camphor	2 *gros.*

We must select the most transparent sandarach, and that which is the least yellow; but if it be not of the best possible kind, we must wash it in a weak ley of potash, and then in a large quantity of water, and let it dry perfectly. For the quantity above directed, we must take a bottle of white glass well dried and of the capacity of forty ounces, and after pulverising the sandarach, we reduce the particles of it to a kind of thin paste, by triturating it with some of the spirit of wine, and put it by degrees into the bottle. We likewise mix the turpentine and the oil of turpentine together, by rubbing them up in the same mortar, and when the turpentine becomes more liquid, we may increase its liquidity by adding some spirits of wine to it and pour it into the bottle, when we must shake it for some time in order to mix the materials well together. We likewise put the camphor into the mortar, and beat it up with some drops of spirit of wine: we then add a larger quantity of the spirit, which will entirely dissolve it; this is then to be poured into the bottle, and it must be again well shaken for some time, and in order thoroughly to mix all the ma-

terials together. The bottle must then either be exposed to the heat of the sun or that of a warm stove for ten or twelve days, taking care to shake it from time to time, and to unstop it, in order to suffer the vapour to escape; but finally it must be close stopped and the varnish kept for use.

On applying the Varnish to Wood.

We place the subjects which we would varnish, either in the sunshine or near a warm stove. We then apply six, eight, or ten coats of varnish. We must take care never to apply a second coat until the former one has become quite dry. If we would give the piece of work a fine lustre, we may polish the varnish after the last coat has become quite dry, with finely washed chalk, applied whilst wet upon a soft woollen cloth. Or we may moisten the palm of the hand and rub the varnish with it until it has acquired a perfect polish. Before applying the varnish upon wood, however, we must always prepare it by a coat of glue.

On fixing Prints upon Wood in their natural position, and removing the paper from them.

We select a surface of any kind of wood, the size of the prints. We then moisten a piece of thick drawing paper, of a proper size, and apply upon its surface a layer of thin glue. We then suffer it to dry and give it two or three more coats of the same glue, letting it dry between each coat; we then prepare the surface of this paper to receive the print in the same manner as the wood was prepared, as described in the first part of this article, by coating it with several layers of spirit varnish. We then apply the print and conduct the operation exactly as before, to the period when we remove the last portions of oil by means of starch, and give several layers of varnish. The wood being thus prepared to receive the print by the coat of glue, and several layers of varnish applied in the manner before described, we fix upon it the leaf of drawing paper, bearing the print upon its prepared surface. We then apply a coat of varnish to the wood, and affix the prepared paper and print upon it whilst it is still tacky, and so as to prevent the formation of any blisters or air bubbles between them. When we think that the varnish has become hard, with the help of warm water and a sponge we moisten the glued paper which covers the whole. We then remove that paper, which readily comes off, and with the aid of the warm water and the sponge we cause the glue to disappear from the varnished surface of the print. We then polish it with prepared chalk and finish it as before stated. This process may also be employed not only to apply prints upon the surface of the wood but also upon metals, &c.—(Journ. de la Societe du Bas. Rhin. 1827.)

Test for the detection of Whiting or Gypsum in Flour.—Dip the fore-finger and thumb in a little sweet oil, and take up a small quantity of the flour between them; if it be pure, it may be rubbed for any length of time, and will not become adhesive; but if whiting be present, it very speedily becomes putty, and adheres strongly; the pure flour also takes on a very dark colour from the oil, but adulterated flour is but little altered in colour.

Another test.—Pour a drop of lemon juice or vinegar into a small quantity of the suspected flour; if whiting is present, an effervescence will be immediately produced; but if the flour is pure, no particular effect will be exhibited.—(*Mech. Mag.*)

COMMUNICATION.] [FOR THE MAGAZINE.

CHARTS FOR STAGE-COACHES.

While travelling in a coach, I have often inquired the name of a village, or other objects that have attracted my notice on the road, without obtaining the wished for information. The thought occurred to my mind, that coaches were not so well provided for in this respect as ships; to be sure, the driver, after travelling the same road several times, needs not a *chart* to direct *him*, but passengers travelling for pleasure, or on business, generally wish to know the names and locations of all the important places, or curiosities on the route.

The underside of the roof of a coach is of considerable dimensions, it is unoccupied, except by a piece of oil cloth somewhat ornamented. Now, instead of this, I would have a plan of the road laid down, with the names of the principal places, and every thing remarkable on or near the route, this certainly would be a convenience; it would afford both satisfaction, and amusement to travellers, and save the driver the trouble of answering many questions.

T. C.

Mr. Editor,—Most mechanicks are aware of the difficulty of fitting a band to two series of pullies, so that it shall be equally tight through all its changes. This being a somewhat difficult problem, if any one of your scientifick correspondents will send a solution of it, he will confer a favour on a

Subscriber.